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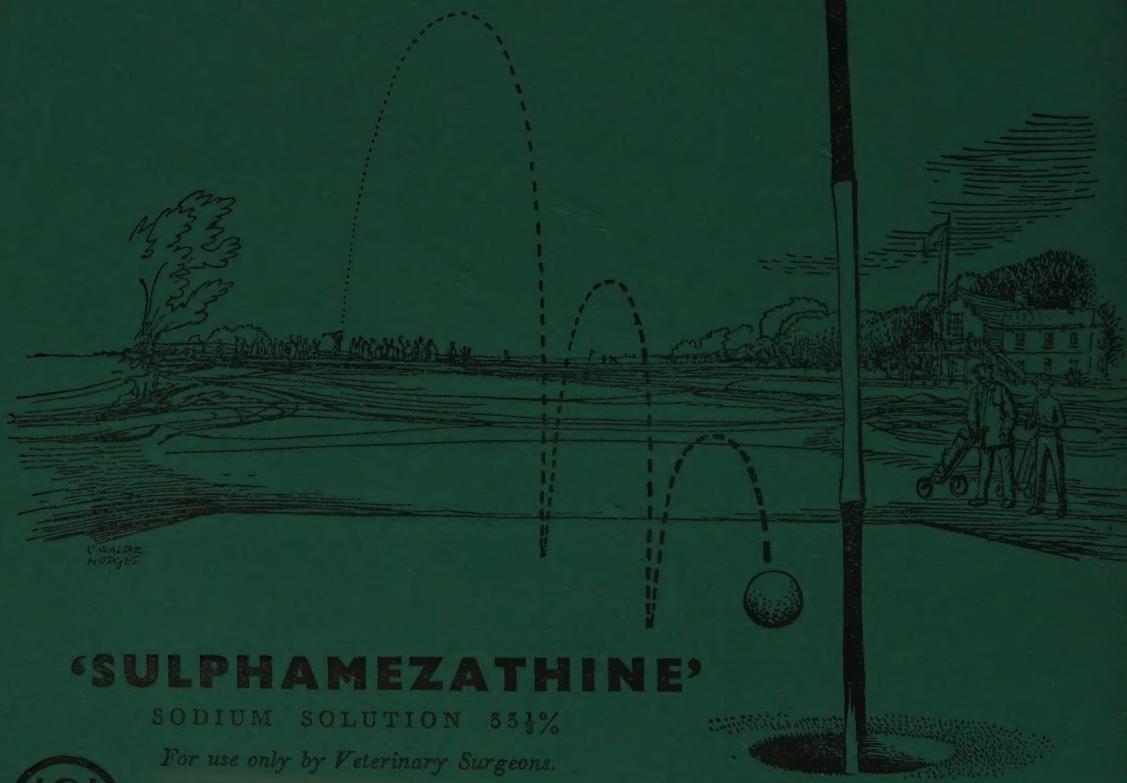
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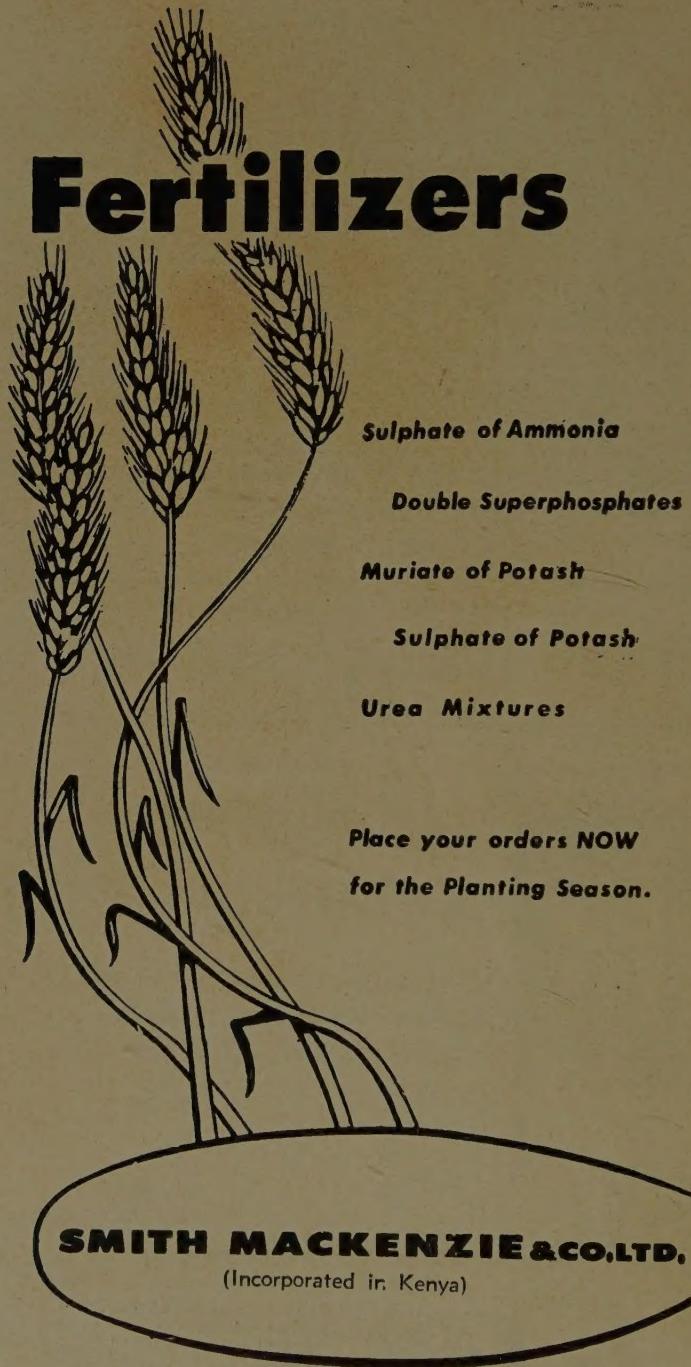
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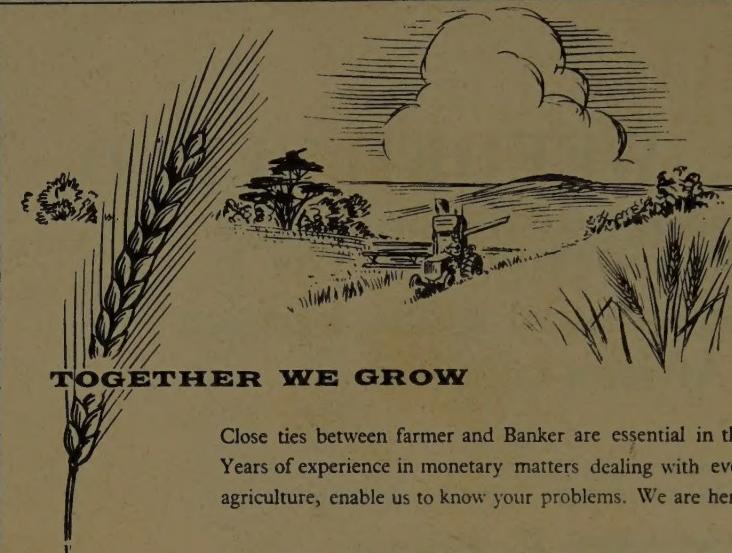


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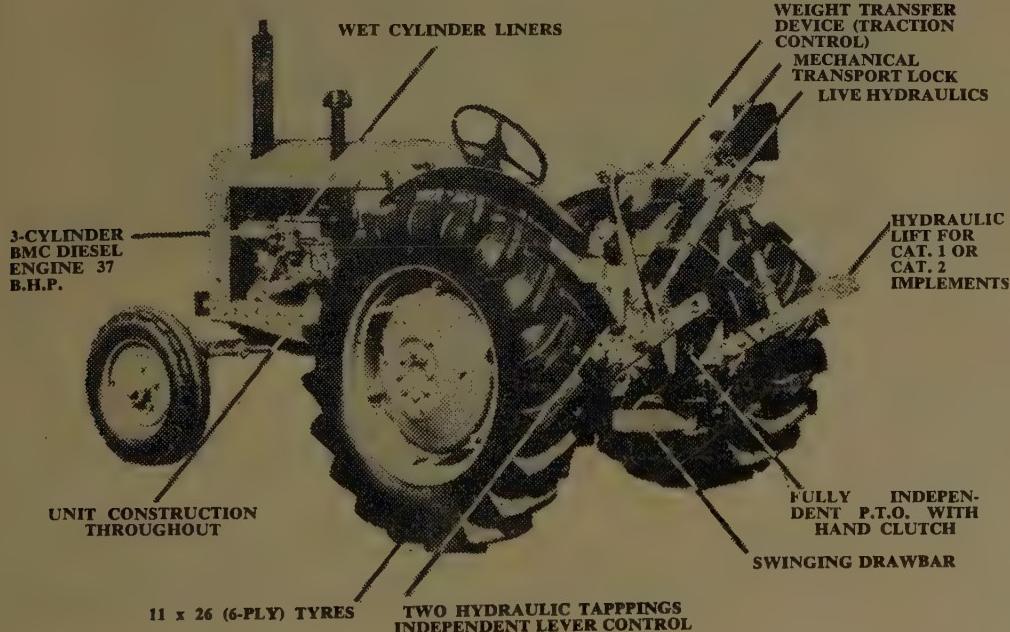
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OCTOBER, 1959

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Readers are reminded that all agricultural enquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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The summary should not be longer than three per cent of the text, and it should be suitable for abstract journals.

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References in the text should either be by number or, preferably, by author's names and date, e.g. Smith *et al* 1954. Numbered references are listed at the end of the paper in numerical order, while author references are listed in alphabetical order. Abbreviations should conform to the World List of Scientific Periodicals: most abbreviations can be found in the reference section of previous papers in this journal.

The following papers give most useful advice on the presentation of technical papers:—

Price, W. C. (1954). Preparing manuscript for Phytopathology. *Phytopathology* 44, 675.

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REPRINTS

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D. W. D.

STOCK POISONING ATTRIBUTED TO THE LEAVES OF THE SHRUB *BERSAMA ABYSSINICA*

By K. W. Harker and R. N. Gourlay, Animal Health Research Centre, Entebbe, Uganda

(Received for publication on 13th July, 1959)

Investigations following the deaths of three milking cows on the Livestock Experimental Station, Entebbe, indicate that the leaves of *Bersama abyssinica* were probably the source of the toxic agent. This species has not, as far as we know, been previously incriminated in stock poisoning, and as the plant occurs extensively in East Africa the preliminary findings are recorded below.

During the 1930's Mettam examined over a hundred plants in Kenya and Uganda for possible toxic agents [1, 2, 3]. His method appears to have been to select plants from families or genera which contained known poisonous plants and to feed them to rabbits. Using this technique a number of toxic plants were found but, in spite of the systematic removal of these plants from the paddocks at Entebbe, occasional deaths, attributed to some unknown poison or poisons, have occurred from time to time.

At 7 a.m. on the morning of Friday, June 5th, 1959, five cows in the milking herd were sick. By 8.30 a.m. one had died and two more died at 11.30 a.m. and 4.30 p.m. respectively after showing severe nervous symptoms. The remaining two recovered within a few days. The history and clinical picture suggested poisoning but rapid tests for arsenic in the stomach contents of the dead animals and for hydrogen cyanide in the stomach contents and in the blood, both before and after death, were negative.

Since other mysterious deaths had occurred in the paddock concerned, it was decided to examine the stomach contents of the first dead animal very thoroughly. The rumen was filled primarily with graminaceous material, but one large seed, one skin of a fruit and a few pieces of green non-graminaceous leaf were found. These latter, all appeared to be pieces of leaf from one specific plant. They indicated, when partially reconstructed, a leaf three to four inches long, broad at the base with a pointed apex and denticulate margins.

A search for this plant was started immediately and was intensified when similar leaf

pieces were found in the rumen of the second and of the third dead cows. This search proved harder than was anticipated. Within the first hour, ten to a dozen leaves, similar to the description above but differing in minor details were found. Examination of leaves was also made difficult because most of the weeds had been slashed the previous day. Eventually, a pinnate leaf with leaflets similar to the pieces from the first stomach contents was found.

During a further search seven shrubs were found. Most of these had been slashed, but two, growing amongst some rocks, were untouched and had both green leaves and flowers (Plate 1). This shrub was named in the herbarium of the Forest Department, Entebbe, as



Plate 1.—A *Bersama abyssinica* shrub

Bersama abyssinica Fres. sub sp. *abyssinica*. Verdcourt. According to Eggeling and Dale the species occurs in the Mengo, Ankole, Kigezi, Toro, Bunyoro, West Nile, Mbale and

Busoga Districts of Uganda [4]; in Tanganyika many species of Bersama, which may now only be regarded as subspecies of *Bersama abyssinica*, are given in the check list of the forest trees and shrubs [5]; and the genus is also well represented in Kenya [6]; *Bersama* spp. also occur in South and West Africa [7], [8].

Examination of dried herbarium specimens indicates the very wide variation of material now included under *Bersama abyssinica* sub sp. *abyssinica* and observations in the field point to the difficulties of separating this species, in the vegetative phase, from other similar genera. The inflorescence is, characteristically, a pendulous raceme up to 18 inches long, with small five petalled white to cream flowers packed tightly along the central axis. The flowers mature in succession and usually drop after flowering. Fruits are not common in Uganda. The leaves are alternate up to 2 ft. long with three to 14 opposite or subopposite pairs of leaflets and a terminal leaflet. The leaflets are shortly petiolulate from ovate to oblong-lanceolate in shape; from one to eight inches long, with entire or dentate margins and with pointed tips.

The shrub ranges from a single stem two or three feet in height to a small straggling tree of 20 ft. A useful field character is the horseshoe-shaped scar left by the shed leaf (Fig. 1) The young twigs are usually densely covered with short brown hairs.

A search of the available literature and questioning of the local populace indicated that the toxicity of leaves of *Bersama abyssinica* may not have been previously suspected. The bark, however, was used by the Zulus to relieve menstrual pains [7] and in West Africa the roots, the fruits and the bark of sub sp. *paullinioides* have medicinal properties [8]. In Uganda, Toro women use an infusion of the green leaves in the treatment of children with dysentery.

Against this doubtful background it was decided to observe the reactions of rabbits when fed the leaves. A rabbit was offered leaves which had wilted for six hours; the animal readily consumed a number of leaflets and within an hour it showed signs of lack of muscular control and within six hours it was dead. A second rabbit, which weighed just over 2 kilos was then fed weighed quantities of fresh leaflets. This animal consumed under 2 grams of leaf; equivalent to a quarter

of a gram of dry material and after exhibiting similar symptoms died ten hours after feeding.



Fig. 1.—Flower, shoot tip and a leaf of *Bersama abyssinica*

This proved that quite small quantities of the leaves of our *Bersama* sp. were lethal to rabbits but did not necessarily prove that this was the cause of death of the cows. A calf six months old and weighing only 82 pounds was offered the leaves but did not touch them. Consequently it was drenched with 4 grams of dried leaves which had been roughly ground and suspended in water. First signs of weakness occurred after six hours and the symptoms followed a similar sequence to those observed in the cows that had died, with the difference that the experimental animal survived longer. The maximum interval from possible time of eating to death was 12, 15 and 20 hours respectively for the three cows, whilst the experimental animal was destroyed *in extremis* after 25 hours.

Post mortem examination of the experimental animal showed a similar indefinite picture to that seen in the dead animals. Thus, we feel there can be no doubt that the cows died of *Bersama* poisoning. Why the cows ate the leaves is still a mystery.

The toxin still remains to be identified and we know nothing of the regional or seasonal incidence of poisoning due to this species but

we are prompted to publish this preliminary report in order to warn stockowners that this plant is a potential danger, especially if the shrub is cut and cattle are allowed access to the partially dried leaves.

ACKNOWLEDGMENTS

We wish to acknowledge the assistance and team spirit of our colleagues, in particular Mr. L. Barber for assistance with experimental animals; Mr. C. D. Juko for chemical tests; Mr. G. D. Lomax for the photography and Mrs. V. G. Harker for the drawing and for locating the shrub in the first instance. We are very grateful to Mr. H. C. Dawkins, M.B.E., Forestry Department, for his assistance in identifying the plant.

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REVIEW

REPRODUCTION AND INFERTILITY. III—Symposium, 1958. Edited by F. X. Gassner. Pergamon Press, London, 270 pp., price 42s.

This book records the papers read at a Symposium, held at Colorado State University in July, 1957, together with the discussions on those papers. There are author and subject indexes and a list of members of the Symposium.

Although these biennial symposia are for human and animal specialists in the fields of reproduction and fertility, this book which reports the third symposium is likely to be of most interest to those working with cattle and sheep.

Following the opening address on radioactive fallout, there are five section dealing with various topics of reproduction and fertility, or lack thereof, in which recent advances have been made.

Section I on "Diseases of reproduction in Male and Female" is concerned solely with cattle and sheep, covering vibriosis, catarrhal vaginitis ("epivag"), epididymitis and neoplasms of the genitalia.

In Section II, "Ovarian Physiology" is considered in five papers including cytological changes, neural relations, and a report on an

interesting attempt at treatment of 50 repeat-breeder cows.

Section III, entitled "Steriod Physiology and Therapy", covers bio-synthesis of steriods, the use of some in maintaining human pregnancy, and their occurrence and detection in cattle and swine.

Section IV on "General Problems of Reproduction" ranges from the control of oestrus in cattle through three papers on various aspects of infertility and its treatment, mainly in cattle, to a classification of hypogonadism in the human male.

Section V has one paper on the study of semen metabolism using isotopes, and a discussion on artificial insemination.

The well-edited lively discussions add to the value of many of the papers, which, while generally maintaining a high standard, vary from reports on experiments to more comprehensive reviews of recent work. A useful and often extensive list of references is given at the end of each paper.

Both research workers on reproductive phenomena and abnormalities and those called upon to investigate and correct problems of infertility and breeding diseases will find much of interest and usefulness in this book.

G.D.P.

THE CULTURE OF TILAPIA NIGRA (Günther) IN PONDS

II—THE INFLUENCE OF WATER DEPTH AND TURBIDITY ON THE GROWTH OF MALE *T. nigra*

By Vernon D. van Someren and Peter J. Whitehead, Fish Division (Research), Ministry of Forest Development, Game and Fisheries, Kenya Colony

(Received for publication on 23rd May, 1959)

As part of a general programme of investigation of the factors affecting growth in *Tilapia nigra*, series of experiments have been conducted in a block of half-acre ponds at the Inland Fishery Research Station of this Ministry at Sagana (altitude 3,940 ft.). These ponds are laid out and numbered as follows:—

A1	A4
A2	A5
A3	A6
	A7

METHODS

Fish stockings

The first series of experiments were started in July, 1958, in order to study—

- (a) the effect of water depth on fish growth with equivalent stockings;
- (b) the effect of stocking rate on the growth by means of single stockings; multiple stockings on a time interval basis; and multiple stockings at one time only.

With only seven ponds available, it was possible to replicate only three of the trials at once, and the effect of a multiple stocking at one time only, was a single trial. All the ponds were stocked with male *T. nigra* only, taken from a heavily stocked breeding pond and sexed by examination of external genitalia (Brown, 1955), in order to eliminate further breeding and stabilize the population. The ponds were filled and stocked as follows—

A1 and A7. N fish. Shallow water (average depth 1 ft.).

A2 and A6. N fish. Deep water (average depth 2 ft.).

A3 and A4. N + n + n + n.....fish, the time interval being one month, and three + n stockings being made. Deep water (average depth 2 ft.).

A5. 2N fish. Deep water (average depth 2 ft.).

All the ponds were stocked within the same week, and in all cases N and n were 100 fish, a very low stocking rate since it was desired to study maximum growth rate and not maximum yield.

At the time of stocking, 25 of each of the 100 fish stocked in each pond were tagged with individually numbered plastic tags, and with the + n stockings in A3 and A4, not only were 25 of each of these batches tagged individually, but the remaining 75 in each lot were given single or combination fin clips in order to distinguish the successive stockings from each other. This fin-clipping technique has been reported on by van Someren and Whitehead (1959a).

The purpose of these markings was twofold. Firstly to obtain some estimate of the efficiency of sampling in the monthly seine-nettings made in each pond, and secondly, from the proportional recoveries of tagged to untagged fish each month, to obtain estimates of mortality during the course of the experiments, which could be checked on a final drain-down of each pond.

At the time of stocking, the tagged fish averaged some 1-2 cm. longer than the unmarked fish, and because of this their rate of growth is not similar over the same period of time, an aspect which will be dealt with in a later paper. Apart from this difference, however, neither tagging nor fin-clipping have been found to affect either survival or growth.

The monthly growth of each group of fish calculated from length measurement of fish sampled each month by seine net, and returned alive to the pond each time. Such monthly disturbance of both the fish and the pond may possibly affect growth rate, but the extent of this is not yet known.

The actual rates of growth per month of male *T. nigra* under these conditions are not detailed in this present paper, only the final

sizes achieved after six months' growth. It has been apparent however that even after the first month, the replicated experiments did not give the same results, and that the pond conditions themselves were exerting an influence on growth apart from the basic variations in stocking density.

ENVIRONMENTAL CONDITIONS

Climatic conditions for the Station are recorded from twice daily meteorological readings from a Stevenson Screen, supplemented by 24-hourly records of total rainfall, evaporation, wind speed and direction, and daily hours of sunshine (Campbell-Stokes Recorder).

Hydrologic conditions in the ponds themselves were checked by—

- (1) continuous water temperature measurements on a weekly chart basis, at the bottoms of ponds A1 and A4 for the first six months, and later in ponds A4 and A3. Only two ponds could be measured at one time, owing to lack of instruments, and the two Negretti-Zambra thermographs were frequently checked by spot readings on an independent thermometer and also against each other for accuracy.
- (2) Once weekly estimations of dissolved electrolyte content of the water, as determined by conductivity readings with a Dionic Water Tester.
- (3) Once weekly estimations of turbidity from measurements of samples with an Eel Absorptiometer, these being expressed as percentage transmission of light through a sample of known volume (1 or 2 c.c.), using monochromatic light (606 filter).

The ponds differed from one another in physical and chemical characteristics, the main visible difference being in the degree of turbidity of the standing water, which was unaffected by the weekly topping-up operations required or the monthly netting.

Samples of the turbid water from each pond have been kindly examined by the staff of the East African Agriculture and Forestry Research Organization, and it is clear that the turbidity is not biological in nature (i.e. plankton), but is probably colloidal being caused by base exchange and precipitation.

The seven ponds between them cover $3\frac{1}{2}$ acres, and though adjacent to each other have not been made on the same underlying soil. Ponds A1, A2 and A4 lie on a block of pure "black cotton" soil or clay, in which are embedded frequent calcareous nodules, the whole being of typical catena classification and volcanic in origin. Ponds A3, A5, A6 and A7 on the other hand have been constructed where there are varying admixtures of greyish to reddish soil. These latter ponds show a milky turbidity to varying degrees, but in the former the water when undisturbed settles to a very clear supernatant.

TABLE I.—ANALYSES OF POND SOILS

Pond No.	pH	Exchangeable calcium milliequivalents per 100 gms. soil	Free carbonate as calcium carbonate %
A1	7.9	14.0	0.5
A2	7.7	15.3	1.3
A3	7.4	27.6	0.4
A4	7.6	22.4	0.3
A5	7.6	16.7	0.3
A6	7.4	26.7	1.0
A7	7.4	19.3	0.3

Analysis of calcareous nodules:

Moisture	2.16
Acid insoluble (silica)	12.54
Loss on ignition (CO_2 and organic matter)	34.60
des of aluminium iron, phosphate	11.03
Calcium oxide	39.10

Table I gives analyses of the soils and nodules from these ponds, made by courtesy of the Scott Agricultural Laboratories in 1950 and 1957 before filling the ponds with water. It will be noted that there is a tendency for the turbid ponds such as A3 and A6 to show a higher proportion of exchangeable base, though the relationship is not exact with such small spot samples. In general the soils have been classified as "immature, deep, dark and impermeable clays, with a high content of magnesium and calcium. Reaction of all the samples was alkaline, and all contained considerable quantities of free calcium and magnesium carbonates. Available phosphate was very variable. The nodules consist mainly of calcium carbonate, and are by ordinary standards insoluble".

The turbidity of the water is persistent only in the presence of the appropriate mud. Samples of water from each of the ponds have been held in sedimentation flasks in the laboratory at Sagana for several months, one series containing water only, the other containing the same quantity of water overlying

a one-inch layer of mud from each of the respective ponds. In the flasks without mud, the water from the turbid ponds has cleared completely in about two months. In the flasks which contain mud in addition, the water from ponds A3, A5, A6 and A7 is still almost as turbid as when first taken, as it is in the ponds, but the water overlying mud from A1, A2 and A4 has cleared as it has in these ponds. Moreover, each flask has developed its own distinctive microflora and microfauna, which is rich in the clear samples from ponds A1, A2 and A4, and poor in the turbid samples, the general impression being one of restricted fertility in the turbid ponds.

RESULTS

Tables II and III detail the results for both the fish growth and analyses of pond conditions for the six months of the experiments,

In Table II only the average weights and lengths of fish at the end of this six months are given, since the purpose is to show the variation in final size caused by environmental conditions.

Ponds A1, A2 and A5 were drained after six months, and the average lengths given are those for all fish recovered. The remainder of the ponds are still under observation for a further six months, hence the average lengths for fish in them are those for a sample measured at the sixth month. It is known that

this sixth monthly sample consisted of at least 50 per cent of the fish still present in each pond, and is fully representative of the population in each.

For ponds A1 and A2, survival figures are those from fish actually counted on draining. Since each pond requires about 24 hours fully to empty, these figures may be somewhat low, since opportunities for predation by birds and swamp mongoose during this time are greater. For the two remaining ponds stocked at 100 fish each, the survival figures are calculated from nettings, and bear a close resemblance.

For these four ponds stocked at comparable rates, the rate of mortality appeared to be entirely similar during the six months, and heaviest in the first month after stocking. It is thus reasonable to assume that the variations in final length shown are due to environmental conditions and not to variation in population density during the experiment. It is known from other results that the length at any given time, and the rate of growth during a given period, are most sensitive to the stocking density, other factors being equal, hence it is necessary to eliminate variability due to this factor. In this respect therefore ponds A1, A2, A7 and A6 are between themselves comparable. Pond A5 at 2N stocking is not comparable with any other, but A4 and A3 are comparable with each other, apart from the slight difference in survival whose significance will be discussed presently. With these latter

TABLE II

CLASSIFICATION	POND NO.						
	A1 Shallow clear	A2 Deep clear	A7 Shallow turbid	A6 Deep turbid	A5 Deep turbid	A4 Deep clear	A3 Deep turbid
Average depth feet ..	1	2	1	2	2	2	2
Average per cent trans. light, weekly ..	98	96	93	84	81	95	80
Average E.C. weekly ..	115	148	148	225	111	157	168
Water temperature:							
Average weekly hours at or above 80°F ..	51	—	—	—	—	31	5
Average weekly degrees above 80°F ..	35	—	—	—	—	9	1
Percent survival fish at 6 months	68	63	65	65	57	92	84
Stocking size (cm.):							
Tagged	9.4	9.2	9.7	9.2	9.3	10.0	9.2
Untagged	6.6	6.9	7.3	7.0	7.0	6.9	6.7
Size at 6 months (cm.):							
Tagged	24.7	21.4	20.8	19.9	19.9	19.7	16.5
Untagged	24.9	20.8	21.0	20.5	19.0	18.7	16.1
Increments at 6 months (cm.):							
Tagged	15.3	12.2	11.1	10.7	10.6	9.7	7.3
Untagged	18.3	13.9	13.7	13.5	12.0	11.8	9.4
Average weight at 6 months (gm.):							
Tagged	255	170	160	135	135	130	80
Untagged	260	160	165	150	120	115	75

two ponds, the survival figures and lengths given are those for the first stocking of N fish only, and not for the + n groups. All the N fish were cropped out at the sixth month, leaving the + n fish still alive in the ponds, thus also the figures are actual counts of all N fish surviving, and lengths are averages for all fish recovered, and not samples.

The weights for all fish given are those calculated from a generalized length/weight curve already constructed for male *T. nigra* in monosex culture at Sagana.

In Table II, ponds A1, A2, A6 and A7 have been arranged in descending order of fish length achieved in six months. It will be noted, that when thus arranged these four ponds also fall into order as regards both turbidity and conductivity. Thus fish growth has been better in both clear ponds, as opposed to both turbid ponds, and within this series growth in the shallow clear pond is better than in the deep clear pond, and growth in the shallow turbid pond better than in the deep turbid pond. Since average size at stocking varied slightly, the total increments in six months are a better indication of growth than actual final length, though the same descending order is seen in both final length and increment per six months. Moreover, it is interesting confirmation that the same order of decreasing size occurs in the differing size groups of both tagged and untagged fish in each pond, both groups of fish being influenced in the same way.

In general at the two extremes of shallow-clear and deep-turbid in this comparable series, fish grown in the former conditions showed an advantage of some 26 per cent greater length, and 43 per cent greater weight than fish in the latter over the same period of time.

The averaged weekly conductivity figures show an ascending order with a higher proportion of dissolved electrolytes in the more turbid ponds, a feature referred to presently.

Since the stocking rate was not replicated, Pond A5 is anomalous, but it falls as expected, being a 2N stocking, midway between the N stockings and the + n stockings as regards final length in six months.

Ponds A3 and A4 are not quite comparable as regards survival, and hence final density of the N fish, but in spite of a slightly higher density of fish at the end of six months, the fish in A4 have shown a 25 per cent advantage in length, and a 35 per cent advantage in weight over those in the more turbid A3. Although not shown in the Table, this higher

density of fish is also present in the + n stockings in A4, but this greater population density has not been able to offset the advantages given by clarity in this pond. Both ponds have almost comparable conductivity figures.

TABLE III

Pond No.	WATER TEMPERATURE						Total hours sunshine	
	Total hours at or above 80°F			Degree above 80°F				
	A1	A4	A3	A1	A4	A3		
Week beginning								
20-10-58	72	47	—	50	16	—	53.3	
27-10-58	68	39	—	48	12	—	66.0	
3-11-58	56	35	—	37	12	—	60.3	
10-11-58	74	39	—	53	12	—	57.0	
17-11-58	71	45	—	56	12	—	65.7	
24-11-58	55	35	—	44	8	—	54.4	
1-12-58	28	18	—	22	6	—	42.2	
8-12-58	22	6	—	19	1	—	38.8	
15-12-58	40	36	—	33	11	—	36.5	
22-12-58	47	11	—	27	1	—	67.2	
29-12-58	38	13	—	28	4	—	61.6	
5-1-59	49	52	—	26	20	—	73.9	
12-1-59	49	45	—	28	2	—	63.1	
19-1-59	50	7	—	24	1	—	44.7	
23-2-59	—	6	0	—	3	0	57.2	
2-3-59	—	33	4	—	9	1	63.8	
9-3-59	—	21	4	—	5	1	70.9	
16-3-59	—	51	16	—	17	4	65.5	
23-3-59	—	54	1	—	15	1	57.2	
30-3-59	—	25	6	—	8	0	61.3	
Averages	51	31	5	35	9	1	58.0	

In Tables II and III, the pond characteristics for turbidity (percentage light transmission), and temperature (A1 and A4) are the averaged weekly readings over 21 weeks of the experiment. Temperatures have been recorded in two ways; on a time basis for average weekly hours of water temperature at or above 80° F. (26.75° C.) calculated from the charts, and as a day/degree summation (D°) weekly of all daily temperatures above 80° F. The former method gives an estimation of the total time of heat retention of the water above 80° F., while the latter gives more weight to the actual maxima reached each day. Both thus express different facets of the same feature, and they are more indicative of conditions than averaged daily maxima.

In these experiments, it has not been possible to achieve the ideal of continuous water temperature recording in all ponds simultaneously. But since the ponds form a compact block, are all of the same dimensions, subject to the same insulation, and recording bulbs are placed at similar depths, it can be assumed that temperatures would be similar in ponds of similar characteristics.

For the first period, temperatures in A1 and A4 form a comparable series for a deep and a shallow pond both with clear water, and it is reasonable to suppose that the temperature régime in the other deep clear pond, A2, would have been similar to that in A4, since there are no grounds for assuming that different numbers of fish make any difference to water temperature. For the later months, it was possible to record the variation in a deep turbid pond A3, for comparison with the continuing records in the deep clear A4, and thus for this subsequent period at least the effect of turbidity on temperature can be assessed in water of equivalent depth. Probably therefore, the A3 records are a reflection of the conditions in A6.

The breakdown of the temperature records on a weekly basis is indicated in Table III. The correlation between total weekly hours of sunshine and water temperature is reasonably close as would be expected. There are, however, at the same time definite seasonal swings in average maxima during the year, according to cloud cover and total sunshine in the various months, and these are reflected in seasonal growth patterns of the fish, which are not shown here since they do not affect the present results, which are based on final lengths achieved during the same growing period in each pond.

The figures show that the shallow clear pond A1 maintains water warmer for longer periods than any of the deep ponds, and that in deep ponds of the same depth, those in which the water is clear maintain a slightly higher temperature than those in which the water is turbid. In the shallow ponds, however, the daily recordings show a slightly greater diurnal swing than do deep ponds, and clear ponds similarly show a slightly greater swing than do turbid ponds. In all cases, however, this swing is greater on the side of maximum temperatures, and mean minimal temperatures in all ponds are remarkably similar.

The mechanism of heat absorption and retention requires more detailed investigation in such ponds. In this connexion, it should be noted that the turbidity in the turbid ponds was not of a dark variety such as might be expected to be heat-absorbing, but consisted of a milky-white opalescence which could on the contrary be heat-reflecting; whereas by contrast, the dark mud bottom in the clear ponds probably facilitates heat absorption.

DISCUSSION

The results indicate clearly that other factors such as stocking density and mortality being equal, considerably better fish growth can be obtained in ponds which are shallow as opposed to deep, and clear as opposed to turbid.

There are a number of factors associated with shallowness and clarity which would be advantageous to a fish such as *T. nigra*. The obvious one of temperature is considered below, but apart from this, ponds which are as shallow as one foot are probably not subject to thermal stratification, and nocturnal reduction of dissolved oxygen, which leads to curtailment of fertility (Newell, 1957). They will at all times on the contrary show a maximum overturn of water in contact with the bottom mud. A greater clarity of water will also allow maximum light penetration and hence enhanced growth of algae on the bottom mud. *T. nigra* are entirely grazers, digesting only the diatoms in the algae ingested, and hence are not dependent on a heavy planktonic growth but on a heavy epilithic or epiphytic growth of diatoms which would be encouraged on a mud surface receiving maximum lighting.

These factors will require examination with more refined techniques later. It may be significant that the more turbid ponds show a higher concentration of dissolved salts—almost as if such could not be utilized sufficiently fast by pond algae because of other limiting factors such as lower temperature or insufficient light.

The effect of higher temperatures in themselves enhancing metabolism and growth have been noted in many different fish species, mainly under controlled aquarium conditions where temperature alone was a variable. Brown (1957) has summarized most of the recent work on this, and most fish show an optimum temperature range in which growth is optimal. As regards *Tilapia* species, the effect of higher temperatures in enhancing growth of maximally fed fish has been demonstrated under controlled aquarium conditions by the staff of the East African Fisheries Research Organization (E.A.F.R.O., 1959).

The markedly different temperature régimes shown in Table III could therefore in themselves account directly for the fish growth differences observed, this being greater in warm water. At the same time, higher temperatures would also be effective in increasing

both the solubility of salts in the warmer ponds and the growth of diatoms directly, thus again increasing the fish growth. It is very noticeable that during hot sunny days *T. nigra* prefer to graze in shallow water, where perhaps photosynthetic activity of algae is highest. Neither the optimum, nor the upper lethal temperatures for *T. nigra* are known, but these fish are still fully active at temperatures up to at least 85° F. (29.5° C.).

The present findings have immediate practical application in fish culture work, where the aim is to induce maximum growth in the shortest time. Obviously this will be achieved best by growing fish in shallow clear ponds, and some restriction of growth must be expected if the pond is deep or turbid. This is at variance with fish culture findings recommended elsewhere, where depth is said to be an advantage (Mortimer and Hickling, 1954), and a high turbidity (due, however, to plankton, and not colloidal) also advantageous. But all these findings have applied to fish other than *Tilapia*, such as carp, and for diatom grazers such as *T. nigra*, shallowness and clarity are obviously better.

Further, these findings also have an economic application, when fish ponds are first constructed. These particular experiments have been run at depths of one and two feet, but we have already found from trials elsewhere that excellent growth is achieved in water as shallow as nine inches only, but not less. Therefore, it is no longer necessary to construct standard deep fish ponds with correspondingly large bunds and massive outlets which are expensive, for the fish will grow better in water of only nine inches to one foot deep which can be retained by much smaller bunds thrown up on any suitable flat area and made watertight—similar in fact to the construction of a rice field. Such smaller bunds are cheaper to construct, and for drainage a small portion of the bund can be dug away to let the water out, and as easily rebuilt, thus saving the expense of masonry outlets.

On the control of turbidity, much depends on the type of soil which is flooded and on local conditions. The results indicate that if turbidity is present in a pond, every effort should be made to minimize it by whatever means possible, such as chemical or physical precipitation.

In this connexion, it may be noted that the turbidity of a pond also depends to some extent on the numbers and species of fish in

it. It has been frequently observed that where mixed sex populations of *T. nigra* are kept and allowed to breed, the constant disturbance of the bottom by the breeding activity of the fish maintains the water in a much more turbid state than is found in male only monosex ponds. Though isolated males will make nests, full breeding activity is prevented, and water in monosex ponds remains much clearer. This in turn must further enhance the growth of males only, and is another reason why monosex is preferable as an economic culture technique.

One warning however about shallow water culture must be given. At Sagana, the ponds are reasonably well controlled against predatory fish-eating mammals and birds. Elsewhere, they may not be so, and thus losses from swamp mongoose and cormorants for example may be heavy when fish are easily seen in shallow ponds. Even at Sagana survival rates are unexpectedly low, and they would certainly be lower in any uncontrolled area. Nevertheless the advantage of shallow clear water culture are substantial, particularly for a fattening procedure, such as recommended by van Someren and Whitehead (1959b).

SUMMARY

In ponds which have been stocked with equivalent numbers of male *T. nigra*, and which have shown comparable survival rates over a period of six months, the growth of fish has been markedly better in those ponds in which the water is shallow (average depth one foot), as opposed to deep (average depth two feet), and clear as opposed to turbid.

At the two extremes of shallow/clear and deep/turbid, the fish in the former showed an advantage of 26 per cent greater length, and 43 per cent greater weight at the end of the six months.

Analysis of environmental factors have shown that the main feature responsible for these differences is almost certainly water temperature. Ponds which are shallow and clear maintain their water at higher temperatures for longer each day than deep or turbid ponds. Such higher temperatures will in themselves induce faster growth directly, as is well known for other species of fish. At the same time, however, other factors are probably operative; shallow clear ponds will allow of greater light penetration, and hence better diatom growth on the bottom mud, diatoms

forming the main food digested by *T. nigra*. Further, shallow ponds are probably not subject to nocturnal stratification in temperature and dissolved gases which lead to curtailment of fertility.

The turbidity of ponds is greatly increased if breeding is allowed, due to disturbance of the bottom mud by nesting fish, and though males in isolation will make nests, breeding is prevented and disturbance minimal. Thus monosex ponds run much clearer than breeding ponds, which in turn enhances the better growth of males under monosex culture conditions.

These findings have immediate practical application, since it is much cheaper to build shallow bunds on a flat area to retain water at a maximum depth of not more than one foot than to construct standard three- to four-foot deep fish ponds, and with such shallow bunds elaborate outlet systems are not required for drainage. A warning is however

given that predation by birds or other animals may be heavier in shallow ponds than in deep water.

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REVIEWS IN BRIEF

TROPICAL SCIENCE I: The Quarterly Journal of the Tropical Products Institute, published by Her Majesty's Stationery Office, London, price 6s. per number.

This Journal is the successor to *Colonial Plant and Animal Products*. It contains articles and notes about tropical products investigated at the Tropical Products Institute, London. The first number contains, among other things, a useful short summary of work on the utilization of spent tan bark.

HORTICULTURE IN THE BRITISH COMMONWEALTH—AN OUTLINE, 1958, by D. Akenhead, published by Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, price 10s.

More than 35 countries are covered in this brief outline of Horticulture in the Commonwealth.

It is really a list of Research and Experimental Stations, the crops grown and lines of research undertaken by those stations. Horticultural and Agricultural officers will find it most useful as an address book for contacts.

The information given is far too brief to be of much value to research workers. Under the section United Kingdom, it is surprising no mention is made of Botanic Gardens. Kew, in particular, has done, and continues to do, a tremendous amount of horticulture for the Commonwealth.

W.B.M.

JOURNAL OF ANIMAL PRODUCTION, Vol. 1, part 1, published by Oliver and Boyd Ltd., Edinburgh, pp. 95, price 17s. 6d.

This is the first issue of a new journal which has superseded the Proceedings of the British Society of Animal Production.

It is a welcome addition to journals on agricultural subjects as the field of animal husbandry has hitherto lacked a special journal of its own.

The first edition includes 11 widely varied papers, each of which has a direct bearing on current agricultural practice both in England and overseas. As with the earlier proceedings this Journal can be thoroughly recommended, not only to the scientist but also to Agricultural Officers and farmers interested in the latest scientific work.

USE OF TRANQUILLIZERS PRIOR TO THE TRANSPORT OF SLAUGHTER CATTLE

By R. A. Ayre-Smith, Department of Veterinary Services, Kabete, Kenya

(Received for publication on 22nd June, 1959)

Extensive use of tranquillizers has been made in human and veterinary medicine within the last six years. Such drugs appear to produce a block at one or more of the relay centres in the neural pathways associated with abnormal behaviour produced by emotional activity (Bieter 1957). Cerebral centres, necessary for the highest mental processes, are comparatively unaffected.

Reserpine, an alkaloid obtained from *Rauwolfia serpentina*, and synthetic derivatives of phenothiazine have been the chemotherapeutic agents most commonly used for their tranquilizing or ataractic effect. In veterinary medicine the use of phenothiazine derivatives is wide and a large volume of literature supports their value for premedication prior to anaesthesia and for restraint prior to minor surgical procedures (Troughton *et al.*, 1955; Scheidy and McNally, 1958). In addition, they are employed to calm animals before their appearance at Shows and to facilitate the transport of horses (Gould, 1957). It is also reported that the inclusion of small quantities of tranquillizers in the rations of cattle enhances weight gains and feed conversion efficiency. It is postulated that this is due to a decrease in physical activity and their protective effect against environmental stress (Sherman, 1958; Erdheim, 1958).

More recently tranquillizers have been advertised in the U.S.A. for use on slaughter cattle during transport to abattoirs (I.B.E.D., 1959). It is claimed that their use reduces bruising, facilitates handling, reduces weight losses caused by the rigours of transport and reduces the incidence of "shipping fever", a condition prevalent in the U.S.A., which is precipitated by the stress and excitement of transport (Foley *et. al.*, 1958).

In Kenya "shipping fever" amongst cattle being transported to the Kenya Meat Commission Abattoir at Athi River is not a problem, but bruising accounts for a large annual wastage of meat. During 1956 and

1958, 486 beef carcasses originating from European farms were completely condemned because of bruising. This figure represents 22 per cent of those condemned or 0.5 per cent of cattle sent for slaughter from European farms. In addition, approximately 150 sides are down-graded monthly at the Kenya Meat Commission, Athi River, due to bruising and about 20,000 lb. of meat are excised annually for this reason.

From observations made on many thousands of carcasses at the Kenya Meat Commission, Athi River (Ginsberg, 1959), it is quite apparent that some bruising occurs prior to cattle being loaded into railway trucks when they are beaten with sticks. The sharp points of long horns also cause localized but deep muscle damage, and these should be removed. The majority of bruising, however, is believed to occur in the first few hours after loading, during which time the cattle are under considerable stress as a result of an unaccustomed environment.

In an attempt to reduce the effects of this stress, and thereby minimize the incidence of bruising, it was decided to evaluate the effects of two tranquillizers on steers being moved by rail to the Kenya Meat Commission, Athi River, from the Rift Valley.

Chlorpromazine hydrochloride,* a drug frequently used as a tranquillizer in veterinary medicine, was chosen for this work, as was Trimeprazine tartrate.* This latter compound has not been widely used for veterinary purposes but is of value as an anti-puritic and sedative in human medicine. Both synthetic compounds are phenothiazine derivatives.

EXPERIMENTAL PROCEDURE

Trimeprazine tartrate was obtained as a five per cent W/V solution. It was first necessary to determine the optimum dosage of this preparation, and two trials were conducted for this purpose in March, 1959.

* Supplies of Chlorpromazine hydrochloride, "Largactil", and Trimeprazine tartrate "6549 R. P. Tartrate" were made available by May & Baker, Ltd., Nairobi.

Trial One

Two high grade Ayrshire type steers, one grade Shorthorn steer and one grade Shorthorn heifer were selected from a mob of young stock. These beasts were approximately 18 months old and were unaccustomed to being handled. Prior to receiving the drug they were confined overnight in a small paddock with adequate grass and water available. The next morning their live-weights were assessed visually by a team of three. All four beasts were noted to be particularly wild and liable to charge observers entering the paddock. Treatment is outlined in Table I. Injections were made subcutaneously in the neck on the right-hand side.

TABLE I.—DETAILS OF TREATMENTS, TRIAL ONE

Description	Estimated Liveweight Kilo	Dosage Rate of Trimeprazine Tartrate Mg./Kilo Body Weight
Ayrshire Steer No. 1..	300	1·0
Ayrshire Steer No. 2..	300	1·5
Shorthorn Heifer No. 3	275	2·0
Shorthorn Steer No. 4	275	2·5

Observations on their behaviour were made every 30 minutes for a period of five hours after treatment.

Observations—Trial One

It was noted that the drug took 40 to 50 minutes to produce effect, the first observation being that Nos. 3 and 4 lay down. When approached they immediately arose and appeared fully alert. No. 2 was still very wild at this stage. After 1½ hours had elapsed No. 4, who had received the highest dosage rate, was noted to be breathing rapidly, and soon after Nos. 1 and 3 were also seen to have an accelerated respiratory rate. The same tendency to lie down was noted with these three beasts. When they were disturbed they arose and appeared alert. Cudding and grazing were not interfered with, but a tendency to drag slightly their hind feet was recorded. Two hours after dosing the respiratory rate of all four beasts was as follows:—

No. 1	60 per minute
No. 2	33 per minute
No. 3	45 per minute
No. 4	115 per minute

No. 4 occasionally panted. The eyes of No. 1, 3 and 4 appeared dreamy and these three animals could be approached but not touched. No. 2 remained wild. Three and a

half hours after treatment all four beasts were standing and cudding, respirations were normal and they moved away as soon as approached.

Conclusions—Trial One

While a dosage rate of 1½ mg. per kilo body weight did not appear to produce much effect, it was realized that the steer receiving this amount had been especially wild before treatment. The rate of 2½ mg. per kilo had caused respiratory distress. It was, therefore, believed that the correct rate lay somewhere between 1-2½ mg. per kilo; that the drug would need nearly an hour to take effect and that this effect might last for three hours. The tendency to lie down was not considered an advantage for the ultimate purpose of these trials.

Trial Two

Ten grade and ten Boran steers born in 1955 were selected for their uniformity of size. Five groups were formed consisting of two grades and two Borans in each group. Live-weights were assessed visually by a team of three and each animal was numbered. A summary of the treatments appears in Table II. All injections were made subcutaneously into the anterior part of the right side of the neck.

TABLE II.—SUMMARY OF TREATMENTS, TRIAL TWO

Group	Description of Steers	Estimated Liveweight Average per Steer Kilos	Dosage Rate Trimeprazine Tartrate Mg./Kilo Body Weight
1	2 Grade	437	1·0
	2 Boran	450	1·0
2	2 Grade	425	1·5
	2 Boran	462	1·5
3	2 Grade	487	2·0
	2 Boran	450	2·0
4	2 Grade	462	2·5
	2 Boran	450	2·5
5	2 Grade	437	Control
	2 Boran	462	Control

Observations were recorded every 15 minutes for a period of five hours.

Observations—Trial Two

Some sedation was noted within 45 minutes of injection, there being a tendency for certain steers to lie down, but at no time during the course of observations could any great difference of behaviour be noted amongst treated animals. No indication of respiratory distress was recorded. Grazing was not available in the area in which observations were made, but it was noted that cudding appeared to be normal although defaecation was reduced.

All treated steers were remarkably docile 1½ hours after treatment, and could be handled. At this stage they were driven through a crush with ease, but on leaving it they were noted to be aimless and did not respond to attempts to make them re-enter the yard. The four steers which were not treated showed reluctance to enter the crush with the others. Four hours after treatment all steers appeared to be behaving normally. They were alert, restless and could not be handled.

Conclusions—Trial Two

Since no large differences in degree of sedation were noted between the various groups it was considered that the lowest dosage rate of 1 mg. per kilo body weight should be used prior to loading cattle into railway trucks. Any tendency for cattle to lie down in trucks had to be avoided. It was appreciated that treatment would be required approximately 30 to 60 minutes before the cattle were loaded into the trucks in order that the tranquillizing effect should be present during the period when maximum bruising was anticipated.

Trial Three

For the final evaluation of the use of tranquillizers in slaughter stock, 75 steers were chosen. These steers were of low grade or Boran type and were approximately four years old. They were ready for slaughter. Forty-five beasts were taken at random, flank-branded and weighed on 8th March, 1959. They were then moved three miles with the 30 others and rested overnight. Early on 9th March, 1959, the whole mob was moved 11 miles, near to the railway station at Gilgil. On arrival they were again rested for four hours before being moved to the loading yard. Having reached this yard the 30 beasts, which had not been flank-branded, were loaded into two railway trucks.

The remaining 45 were then moved into the yard and four at a time were run into the loading chute where they were treated with one of the following fluids:—

1. Trimeprazine tartrate—5 per cent solution—1 mg. per kilo body weight subcutaneous injection into the most anterior part of the neck.
2. Chlorpromazine hydrochloride—5 per cent solution—0.5 mg. per kilo body weight intramuscular injection in the same region.

3. Sterile water—5 c.c.—subcutaneous injections in the same region.

The correct dose of the two tranquillizers had been determined for each beast prior to its presentation in the chute. Inoculation with the appropriate fluid was therefore made in rotation. Table III gives a summary of the treatments.

The yard and chute facilities for this work were not suitable; and after the drugs became effective the management of the trial was complicated by the aimless behaviour of the steers.

When the time came for the three groups to be separated out prior to loading into trucks according to treatment, it was difficult to work the steers. Eventually it was possible only to load the group treated with Trimeprazine tartrate into a separate truck. The other two groups were mixed and loaded into two further trucks. Two beasts, one of which had received Sterile Water and the other Chlorpromazine hydrochloride, were lost while loading. All railway trucks contained an adequate quantity of grass hay as bedding.

Observations made on the various truck loads, half an hour after loading, revealed that in the two trucks containing the 30 non-treated beasts there was considerable activity. In the two trucks containing a mixture of beasts which had received Chlorpromazine hydrochloride or Sterile Water, activity was considerably reduced, possibly indicating the quietening effect some tranquillized steers were having on others not so treated. In the truck containing the beasts which had been injected with Trimeprazine tartrate there was likewise little activity.

The steers travelled in these trucks for approximately 14 hours to the Kenya Meat Commission Abattoir at Athi River and were then moved into lairage on 10th March, 1959. The next day they were slaughtered. The beasts were examined immediately after killing and observations made on the carcasses during their course across the floor, during which time they were subjected to normal veterinary inspection and grading. The degree of bruising was assessed as "Bad" or "Slight". No attempt was made during this trial to determine the effect of treatment on shrinkage.

Results—Trial Three

Over 30 per cent of sides of the group of 30 non-treated steers were bruised; there were

nine sides (15 per cent) which were badly bruised and ten sides (16.7 per cent) which were slightly bruised. In the treated group of 43 steers there were three sides (3.5 per cent) badly bruised and 12 sides (13.9 per cent) slightly bruised. In a total of 86 sides from treated animals there was under 20 per cent bruised. The nature of the bruising indicated that it had occurred prior to the period in lairage.

This comparison is not overwhelmingly in favour of the treated groups, but it must be remembered that considerable difficulty was experienced during the injection of the fluids under investigation, that subsequent loading operations were also difficult and that two trucks contained a mixture of steers, some of which had been injected with Chlorpromazine hydrochloride and others with Sterile Water.

From Table III it will be seen that no steers, which had received Trimeprazine tartrate, were badly bruised, but that there were six slightly bruised. Of the remaining 38 treated steers three were badly bruised, and six were slightly bruised.

In all cases careful observations were made beneath the site of injection of treated steers, damage to tissues being assessed as "moderate" or "slight". Of the 14 animals which had been injected subcutaneously with Sterile Water there was no sign of any damage to the tissues beneath the site of injection. Of the 14 steers which had received Chlorpromazine hydrochloride there was damage to the tissues in all cases. This damage took the form of a gelatinous mass necessitating the removal of one-quarter to two lb. of

tissue in the region of injection. In the Trimeprazine tartrate treated group of 15 steers, damage was observed beneath the site of ten injections. This damage was similar to that caused by Chlorpromazine hydrochloride. It is not known whether the amount of damage with Trimeprazine tartrate would have been reduced if it had been assured that every injection was given subcutaneously as intended. At the time of injection the effect of the two drugs on tissues was unknown. A region at the top of the neck was therefore chosen to reduce the risk of the condemnation of large quantities of meat should the effect of the drugs be deleterious to tissues. The site chosen did not give much latitude between a subcutaneous and intramuscular injection.

No unfavourable results were noted on organs or flesh in other parts of the body by the use of the two drugs.

DISCUSSION

It is well known that Chlorpromazine hydrochloride is a drug well suited for the tranquillization of animals, any reaction caused at the site of injection being temporary. Trimeprazine tartrate has not been extensively tried for this purpose and these trials show that it has a definite tranquilizing effect on cattle when used at a rate of 1 mg. to $2\frac{1}{2}$ mg. per kilo. The trials also indicate that the lower dosage level of Trimeprazine tartrate may be the one of choice for tranquilization.

The third trial indicates that the use of Chlorpromazine hydrochloride and Trimeprazine tartrate reduces the incidence of bruising during the transport of cattle. The deleterious

TABLE III.—SUMMARY OF TREATMENTS AND RESULTS, TRIAL THREE

Number of Steers	Average Liveweight Kilo, 8-3-59	Average No. c.c. per steer, 9-3-59	Degree of Bruising 11-3-59	Degree of Tissue damage at site of injection 11-3-59
LOT ONE: TREATMENT—TRIMEPRAZINE TARTRATE 15	464	9.2	.6 slight	4 moderate 6 slight
LOT TWO: TREATMENT—CHLORPROMAZINE HYDROCHLORIDE 14	541	5.3	2 bad 3 slight	7 moderate 7 slight
LOT THREE: TREATMENT—STERILE WATER 14	533	5.0	1 bad 3 slight	None
LOT FOUR: CONTROLS—NO TREATMENT 15	—	—	5 bad 6 slight	—
LOT FIVE: CONTROLS—NO TREATMENT 15	—	—	4 bad 4 slight	—

effect of Chlorpromazine hydrochloride on tissues beneath the site of injection prohibits its wide use prior to the transport of stock for slaughter. Further trials are required with Trimeprazine tartrate to determine fully the effect this compound has beneath the site of injection when given by the subcutaneous route, but since such a route cannot be assured under existing loading facilities it is recommended that this compound, in its present form, be not used prior to the transport of slaughter stock.

The existing facilities for loading cattle on to railway trucks in Kenya do not permit of any interference with loading procedure. The ideal tranquillizer must, therefore, have many properties besides its pharmacological action on the nervous system. It should possess a wide margin of toxicity, since it is rare that the weights of steers being moved to slaughter are accurately known. It should be capable of being administered by the subcutaneous or muscular route at any site on the body without causing damage to tissues, and a large volume of fluid should not be required for the treatment of mature cattle. It should be rapidly effective in order that cattle injected during their passage through the loading chute may be moved directly into the railway truck. Its action must also persist for the three-to four-hour period during which time maximum bruising is believed to occur.

SUMMARY

1. Two trials involving the treatment of 20 animals with a solution of Trimeprazine tartrate administered subcutaneously at the rate of 1 to 2.5 mg. per kilo body weight indicate that this compound has a useful tranquilizing effect on cattle aged 18 months to four years.

2. The use of Chlorpromazine hydrochloride and Trimeprazine tartrate prior to the transport by rail of slaughter stock was shown

in Trial Three, which involved 29 treated steers, to reduce the incidence of bruising.

3. Both chemotherapeutic agents, as used in the trial on slaughtered stock, had a deleterious effect on the tissues beneath the site of injection and therefore they cannot be widely recommended for use prior to the transport of such stock.

4. Some of the points required of a tranquillizer, to be used under existing rail loading facilities in Kenya, are mentioned.

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The stock for Trial One were made available by J. Stern, Esq., Rongai, and those in Trial Two by Nderit Estate, Elmenteita. The stock in Trial Three were put at my disposal by Block Estates Ltd., Elmenteita. To the owners and managers of such stock I am deeply grateful.

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THE ACID-FIBRE CONTENT OF LUCERNE IN RELATION TO ITS CONVENTIONAL CRUDE FIBRE CONTENT AT DIFFERENT STAGES OF MATURITY

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The N-H₂SO₄ fibre content of lucerne at different stages of maturity is directly related to its conventional crude fibre content, and the crude protein associated with the acid-fibre is directly related to the total crude protein contained in the legume. These results confirm previous work which dealt with roughages of relatively high crude fibre and relatively low crude protein contents.

In a previous paper it was shown [1] that the 1.5 N-H₂SO₄ fibre content of roughages and the 1.5 N-H₂SO₄ fibre content of roughages corrected for the crude protein associated with the acid-fibre are directly related to the conventional crude fibre content of the same roughages, as determined by the Fertilizers and Feeding Stuffs method. The equations expressing the relationships are:

$$\begin{aligned} 1.5 \text{ N-H}_2\text{SO}_4 \text{ fibre} \\ = 1.95 \times \text{crude fibre (F.F.S.)}^* + 4.20 \dots (1) \end{aligned}$$

$$1.5 \text{ N-H}_2\text{SO}_4 \text{ fibre (corrected)} \\ = 1.265 \times \text{crude fibre (F.F.S.)}^* - 0.34 \dots (2)$$

It was further shown that the crude protein (c.p.) associated with the acid-fibre of the roughage is directly related to the total amount of crude protein contained in the roughage, and the following equation expresses this relationship:

$$\begin{aligned} \text{c.p. in } 1.5 \text{ N-H}_2\text{SO}_4 \text{ fibre} \\ = 0.238 \times \text{c.p. in roughage} + 0.55 \dots (3) \end{aligned}$$

Fig. 1

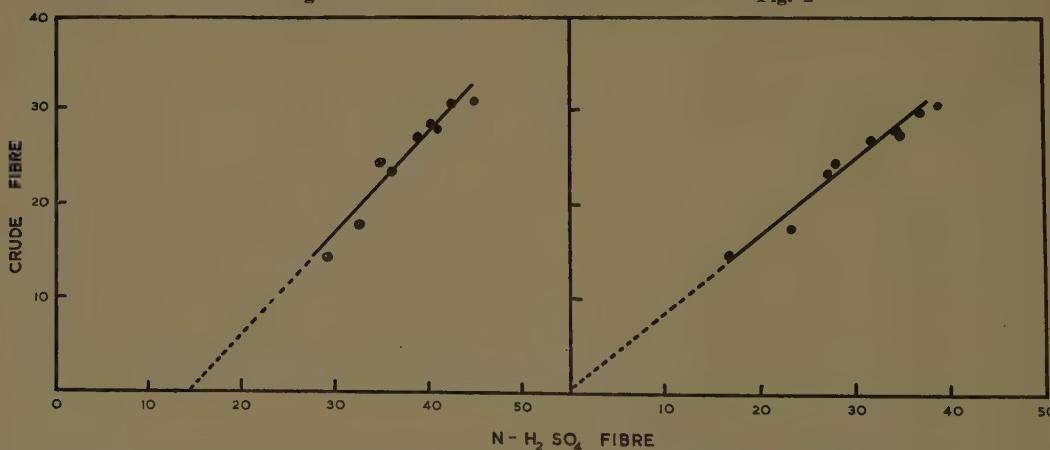


Fig. 2

The roughages used were for the most part a relatively poor source of crude protein, this constituent varying between 4.24 and 15.83 per cent of the dry matter while the crude protein associated with their 1.5 N-H₂SO₄ fibre varied between 1.81 and 2.86 per cent of the dry matter.

In order to seek information on the acid-fibre content of protein-rich material, lucerne in its second year was examined at weekly intervals for nine weeks, during which time the legume completed its growth cycle.

EXPERIMENTAL

18 days after the fourth crop of the year had been taken from the lucerne, the regenerating herbage was sampled for the first time on 1st September, 1958, when it was approximately 6.8 in. high. Thereafter the material was sampled at weekly intervals until the legume had reached the full-flowering stage of growth.

The crude protein content of the lucerne, its N-H₂SO₄ fibre content and the crude protein associated with the N-H₂SO₄ fibre were determined together with the conventional crude fibre.

RESULTS

The results of these determinations are shown graphically in Figs. 1, 2, and 3. Calculations from the data show that there is a direct

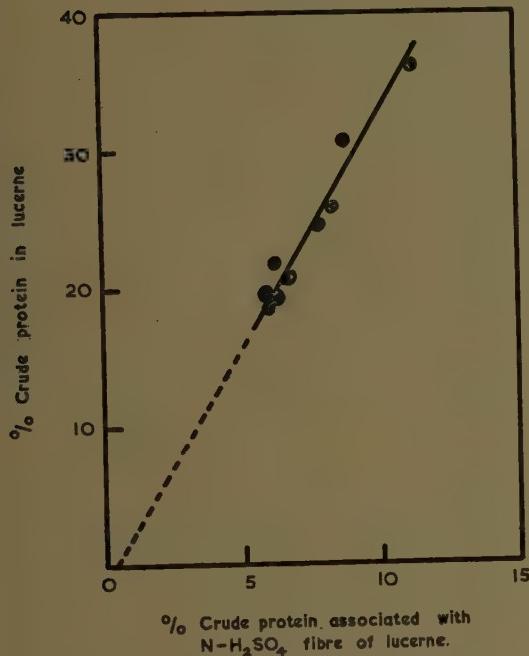
* F.F.S. Determined by the method of the Fertilizers and Feeding Stuffs Regulations.

relationship between the conventional crude fibre content of lucerne and its $\text{N-H}_2\text{SO}_4$ fibre at all stages in its maturity and the following equation expresses this relationship:

$\text{N-H}_2\text{SO}_4$ fibre

$$= 0.936 \times \text{crude fibre (F.F.S.)} + 14.24 \quad (1-r^2 = 0.061) \quad \dots \quad \dots \quad (4)$$

Fig. 3



This equation does not differ significantly from the ap Griffith and Thomas [2] equation for roughages, viz:

$\text{N-H}_2\text{SO}_4$ fibre

$$= 0.798 \times \text{crude fibre (A.O.A.C.)} + 19.074 \quad \dots \quad \dots \quad \dots \quad (5)$$

When the crude protein associated with the $\text{N-H}_2\text{SO}_4$ fibre is taken in account equation (4) is modified, and becomes:

$$\begin{aligned} \text{N-H}_2\text{SO}_4 \text{ fibre (corrected)} \\ = 1.243 \times \text{crude fibre (F.F.S.)} - 0.85 \quad (1-r^2 = 0.044) \quad \dots \quad \dots \quad (6) \end{aligned}$$

This equation does not differ significantly from equation (2).

Further calculations show that the crude protein (c.p.) associated with $\text{N-H}_2\text{SO}_4$ fibre is directly related to the total amount of crude protein contained in the lucerne, and the following equation expresses this relationship:

$$\begin{aligned} \text{c.p. in } \text{N-H}_2\text{SO}_4 \text{ fibre of lucerne} \\ = 0.29 \times \text{c.p. in lucerne} + 0.47 \quad (1-r^2 = 0.038) \quad \dots \quad \dots \quad (7) \end{aligned}$$

This equation does not differ significantly from equation (3).

CONCLUSION

It is apparent that the conventional crude fibre content of lucerne is directly related to its $\text{N-H}_2\text{SO}_4$ fibre content and to its $\text{N-H}_2\text{SO}_4$ fibre corrected for the crude protein associated with the acid-fibre. It is apparent also that the crude protein associated with the acid fibre is related to the total amount of crude protein contained in the legume. The results reported have taken into account a wide range of crude protein and crude fibre values and they confirm the results reported for roughages in which crude protein values were relatively low and crude fibre values were relatively high.

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REVIEWS IN BRIEF

LAND USE MAPS OF THE CENTRAL GAMBIA, produced by the Director of Overseas Surveys, Tolworth, Surbiton, Surrey. Copies may be obtained from Edward Stanford Ltd., Long Acre, London, W.C.2, or Survey Department, Bathurst, Gambia, price 3s. 6d. net.

These are being published as a series of 35 maps, at a scale of 1/25,000. The distribution and extent of woodland, fallow bush, grass, food crops, mangroves and marshes are noted.

LAND CONSOLIDATION IN EUROPE by E. H. Jacoby, published by the International Institute for Land Reclamation and Improvement, Wageningen, Holland, pp. 142, 16 fig. and 2 maps, price \$2.50.

This deals first with the economic and social aspects of land consolidation. It then goes on to discuss the associated problems of legislation, financing and administration. There is also a list of enactments affecting the consolidation of holdings in some 20 European countries.

THE ROLE OF THE VETERINARIAN IN WORLD ECONOMY

By Sir Thomas Dalling, former Chief Veterinary Officer, Great Britain
(Food and Agriculture Organization of the United Nations)

Veterinarians are individuals who have undergone special training and have received appropriate education to fit them to undertake the many duties which fall upon the veterinary profession throughout the world. These duties vary, but are essentially concerned with the health of the animals.

Agriculture occupies an important place in most countries and the maintenance of livestock of different kinds is an essential part in developing any agricultural policy. The wealth of a country is often judged by the numbers and quality of its livestock and in some countries the livestock industry is already in an advanced state: in others, hitherto less developed, more attention is now being given to improvements whereby the demands of human population for proteins of animal origin, at present in short supply, can be met from within a country as well as with expectations that exports of livestock and for livestock products may be possible.

Veterinarians have essential duties with livestock everywhere. For the best results from livestock it is necessary to give attention to three points: (a) the type of animals for the purpose for which they are required; (b) the nutrition of the animals suitable and necessary for that purpose; (c) the health of the animals to ensure that maximum results may be obtained.

It appears often to have been considered, possibly more in well developed countries, that veterinarians are concerned with, and their services used almost exclusively for, the treatment of animals suffering from some disease or injury. This may have been largely true in past years, but it no longer holds good, for, generally speaking, the aim is now to prevent rather than cure disease. Valuable individual animals will certainly continue to have much veterinary attention and rightly so, but the trend today is to deal with the herd or group of animals rather than with the individual. This holds good in all parts of the world although, even in less developed countries, circumstances arise when the individual animal must receive attention, as, for example, valuable imported breeding stock. Although this trend may be looked upon as somewhat of

a new development, many examples can be given of mass treatment of livestock in the control of epizootics carried out by veterinarians.

Veterinarians are, primarily, the custodians and guardians of the health of animals. Their important duty is, therefore, concerned with the prevention of disease, which is any departure from health, taking any action, when considered necessary, to restore health and to maintain and improve health to meet the requirements demanded from the animals. Bearing in mind that animals are kept for specific purposes and that health plays an important part in meeting the demands, veterinarians must concern themselves to some extent also with breeding, nutrition and general management or husbandry of livestock. It is not intended to convey the impression that veterinarians should be responsible for these general subjects: from their training and experience, however, veterinarians are best suited to give attention to the aspects of these subjects which have any bearing on the health of animals. In animal breeding, by artificial insemination, which is now being encouraged throughout the world, the possibility of conveyance of venereal diseases comes within the province of the veterinarian as do the effects on health following the feeding of introduced plants and crops.

Diseases of a highly infectious nature, with the prevention and control of epizootics or enzootics, must always be in the minds of veterinarians in every part of the world: without the practice of control measures the resulting damage can be great, with consequent loss not only to individuals but also to the country's economy. In countries which export livestock and products of animal origin, the losses can be felt over a long period, because importing countries often prohibit the entry of any livestock or their products from countries or areas in which certain animal diseases exist or demand certain conditions which are expensive to fulfil. Modern methods of diagnosis and preventive treatment are gradually reducing the prevalence of many of the recognized infectious animal diseases; the eradication of some of them from some parts of the world is now in sight.

While veterinarians accept responsibility for the care of the health of animals from the point of view of livestock economy, they have also an added responsibility because some of the diseases affecting animals are transmissible to human beings. The group of such diseases, termed zoonoses, is quite large; much credit and appreciation must be given to the medical authorities for their excellent work in the treatment of human beings suffering from such diseases, for their efforts are leading to good results. On the other hand, it must be pointed out that the reservoirs of these infections are animals and, until they are eradicated from animals, the risk of the infection being conveyed to human beings will remain through contact or the consumption of infected animal products. The economy of a country or area can be influenced to a considerable extent by the loss in man-hours due to such infections. Veterinarians, therefore, have a considerable responsibility in connexion with the prevention of human diseases and suffering and have to be considered as "guardians of human health" in some of its aspects.

Again, we have to consider the work of the veterinarians in ensuring that meat and meat products are supplied to the consuming public in a safe and wholesome state. In most countries where large abattoirs are used, veterinarians are responsible for ensuring that all meat and meat products leave the premises in a satisfactory condition for human consumption. This entails the inspection of animals before slaughter, the examination of meat and offal, the condemning of parts considered to be unfit in any way for human consumption, and giving the necessary attention to the cleanliness and hygienic conditions under which all the operations in the abattoir are carried out.

In some countries the duties of veterinarians extend even further and they are responsible for the satisfactory condition in which fish and sometimes all edible products are made available to the public. In such cases their responsibility does not end until the foodstuffs are displayed for sale in the retail shops and markets.

In countries which export meat and products of animal origin, including such items as hides and skins, wool, hair, bones, etc., veterinary certification of their freedom from certain infectious conditions is required by importing countries.

We have discussed livestock and their products; we must not forget, however, the smaller

animals and poultry. Dogs and cats are highly prized in some countries, the former not only for the work it does for man but, together with the cat, for its companionship which adds to the happiness and contentment of the owners. In many towns throughout the world, veterinarians are busily employed in problems of health and disease of these animals and note must also be made that dogs and cats are also susceptible to some diseases communicable to human beings, for the recognition of which veterinarians must always be on the alert.

These are some of the main duties of veterinarians, all of which have some bearing on world economy. Other duties are carried out largely by veterinary services as opposed to practising veterinarians, but sufficient has been said to show the important place occupied by veterinarians in the world today.

No matter how efficient an individual veterinarian or a veterinary service may be in the work allotted to them, they depend on the results of research work for their knowledge of new methods of dealing with problems of animal and human health. It has been truly said that a profession is "dead" without research activities. For many years, veterinary research was starved by the lack of funds and it was left to the keenness of a few, often supported by private enterprise, to engage in the subject. Notwithstanding the many difficulties, these workers made valuable contributions to the general knowledge of the causes, prevention and treatment of animal diseases. In recent years, however, much more financial support from public funds and some further contributions from private enterprise have become available. This has resulted in assuring young men and women a future career in veterinary and other research work; thus, research has attracted more and more personnel and the field is now being covered to a marked degree. More and more research work is being undertaken and problems are gradually being solved. Veterinary activities are also profiting by the results of research work in other branches of science, sometimes far removed from animal diseases, for any discovery which may have a bearing on their work is largely applied by veterinarians. Team work between veterinarians and other scientifically trained personnel is now the "order of the day" and is providing solutions to many problems. Here again, then is a veterinary activity of importance to world economy.

In order that veterinarians may undergo the necessary training and gain experience in the many subjects with which they must be familiar, their education is carried out in veterinary schools or colleges, which are usually part of a university. Every student who enters a veterinary school after attaining matriculation standard in general education is required to pursue a course of study in the subjects of basic science in order that he may appreciate and understand the more applied subjects peculiar to veterinary science and medicine. For the teaching of these subjects, the veterinary student often attends classes along with others reading for degrees in sciences other than veterinary. The more purely veterinary subjects are taught by veterinarians experienced in teaching, and the teaching field is now claiming more and more young men and women with the necessary outlook and aptitude. These individuals are doing important work in preparing veterinary undergraduates for their future careers throughout the world.

Very often these teachers also engage in refresher courses, held periodically and attended by graduate veterinarians, the object of which is to give information on the latest discoveries, the application of which will ensure more rapid and surer results in dealing with animal diseases.

Veterinarians also are employed in laboratories which are largely devoted to the diagnosis of disease and the solutions of problems which present difficulties to veterinarians in the field.

It will be understood that the number of veterinarians may not be in proportion to the number of animals in a country or area, the stage of development of a country and the economic aspects of the livestock industry being closely related to their numbers. It is of much interest, however, to observe that practically all countries throughout the world appreciate now more fully the value and importance of veterinary services; this is reflected in increases in veterinary personnel in many countries and the establishment of veterinary services, even sometimes on a modest scale as a beginning in countries which are now becoming independent.

It can also be appreciated that all the details of the veterinary activities as described in this article cannot always be carried out by veterinarians, especially in countries in which the livestock population is scattered over large areas and in which the economy cannot support

large numbers of graduates of the veterinary profession. Much useful work is being done by laymen, trained for specific duties and working under the supervision of veterinarians. Such personnel have a useful place in the veterinary activities in some countries.

Attention must be drawn to the assistance rendered by international bodies interested in veterinary work. In the further development of some countries, the role played by agriculture has not been omitted and attention is being given by these bodies to the livestock industry. Realizing that animal health is one of the important considerations in assisting the less developed countries in their economy, and the need for producing more and more supplies of protein of animal origin throughout the world, these international organizations collaborate with the governments of such countries by employing veterinarians to visit and often reside in the countries for periods, advising on and participating in the control of animal health and disease. Much valuable work has already been done and these activities will be continued as long as the necessary finances are made available.

The present systems of education for veterinarians throughout the world have much in common and are designed to provide the essentials of training to enable graduates to undertake duties in different parts of the world. It has to be remembered, however, that the actual work required from veterinarians differs according to prevailing conditions in their spheres of activity. In countries in which veterinary services have been long established the work and duties of veterinarians have become, at least to some extent, regulated by public demand and by the economic and sentimental value attached to animals of all species. In such countries, which may be referred to as the better developed countries, livestock is usually more concentrated in relatively small areas, and the number of veterinarians in them is relatively large. On the other hand, in countries in which the animal population is more scattered, extending over wide areas and in which less value is attached to individual animals, there is usually a much smaller number of veterinarians, and their work, in detail, often varies considerably from that carried out in the better developed countries.

One of the main differences between such areas is private veterinary practice. Although state veterinary services are essential for the

control of animal diseases, especially contagious diseases, in all parts of the world, and are found, in some measure, in all countries, private practice is found only to a limited extent in the less developed countries. It may be stated that, generally speaking the work of private practitioners is concerned to a large extent with individual animals or small groups of animals, whereas a state veterinary service deals more with a country as a whole in the application of regulations and extensive schemes to control and prevent the spread of a disease and to ensure that some diseases do not enter the country. In some countries, the state veterinary service, in addition to its veterinarians, makes use of private practitioners in a part-time capacity to assist in its activities and, especially in the less developed parts of the world, the staff may include personnel, trained and experienced in some aspects of the work, which is carried out under supervision of the veterinarians.

In the course of time and as conditions have changed in most countries, the work in private practices has also undergone changes. With the introduction of mechanical methods in agriculture and transport work in many parts of the world, the need for horses is rapidly disappearing, with the result that the mainstay of private practice of some years ago has moved to other animals. The importance now attached to cattle, pigs, sheep, goats and poultry has meant that their owners have become more concerned with the health problems of such animals; in such work veterinarians have been much assisted by the results of research work throughout the world. Again, the interest now being taken in domestic pets, especially dogs and cats, has created a demand for veterinary services to such an extent that many veterinarians now devote their whole time to the care of such animals. Knowledge and information on the health and disease problems of these animals have increased very rapidly in the past two or three decades; the advent of women into the veterinary profession coincided to some extent with the expansion of veterinary activities on small animals. In most of the larger towns, especially in the better developed countries, clinics devoted entirely to small animal veterinary work are to be found. Rapid progress has been made in the surgery of these animals and in such clinics well-equipped operating rooms are usually available, where care very similar to that given to human beings is exercised in dealing with these small animals.

Surgical work on the larger domestic animals has also advanced to a marked extent in recent years, and veterinarians now undertake surgical operations which, at one time, would be considered impossible or attended with much risk. Much of the risk has been overcome by the development of more satisfactory techniques of anaesthesia.

A considerable amount of the time of a veterinarian in private practice must be spent on the farm itself. Until modern transport became available much of the veterinarian's time was occupied in travelling from farm to farm. Today, by the use of motor vehicles and even aircraft, longer distances are covered in a short space of time and, therefore, the activities of veterinarians in private practice have substantially increased in most areas.

Whereas in former times it was uncommon to find more than one veterinarian in a practice, the tendency today is to have a number, co-operating as partners or acting as assistants, in a single practice. This system has many advantages.

Veterinarians in private practice may be appointed for part-time work for a state veterinary service. This may occupy a considerable amount of their time each day, especially in countries where extensive schemes for the eradication of a disease are in progress. On the other hand, in some parts of the world, practically every veterinarian is an employee of the state veterinary service but is permitted also to engage in private practice when it does not interfere with his state duties.

Apart from private practice, veterinarians in the more developed countries are employed on a full-time basis for other duties. Control of abattoirs falls into this category. Such appointments may be made by a government when control of abattoirs is a function of the state. In other cases, local authorities and municipalities are responsible for abattoirs and appoint the necessary veterinary staff. In some parts of the world all livestock for slaughter and the operating of abattoirs and packing plants are carried out entirely by private enterprise. Veterinarians are employed by such companies, usually in a full-time capacity. They may be in actual charge of the different operations or may act as supervisors and advisers. In addition, veterinarians employed by the state also participate in the work.

In the more developed countries, veterinarians in private practice are assisted, especially in the diagnosis of disease, by laboratories

supported by the state. This type of service has received a considerable amount of prominence within recent years and is now regarded as an essential adjunct to the control of animal health and disease. In most countries there is at least one such laboratory; in others, in addition to a central laboratory where both diagnosis and research work are carried out, there exist smaller laboratories located in different areas and equipped and staffed to ensure adequate provision for diagnosis work and for simpler types of research on the more local types of problem. Any problem which requires more facilities than those available at such local laboratories is referred to the central laboratory where extensive research work can be carried out. This system of local investigation of disease problems is proving to be of high value; co-operation between the veterinarians in private practice and the local veterinary investigators is revealing problems of animal health and disease, the solution of which is of considerable economic importance to a country. These local veterinary investigators acquire a large amount of information on animal health problems and often, from their work, the solution of a problem affecting a whole country or area is solved.

More interest is being taken in the health of wild animals in captivity and it is now a normal procedure to appoint veterinarians to zoological gardens to advise on feeding problems, control of disease and the general conditions under which such animals are maintained.

Mention must also be made of the excellent work carried out in a number of countries by veterinarians employed by private or commercial companies for the production of biological and chemical and other products which are now in everyday use in the prevention and control of animal diseases. At such establishments extensive research work is also carried out, and the world, in general, owes much of its knowledge concerning the maintenance of health and disease control to the activities of the veterinary staff there.

In some parts of the world where animals are kept under ranch conditions, veterinarians in private practice give veterinary attention on an extensive scale. Such work embraces the adoption of measures to prevent diseases which are prevalent in the district; vaccines and other biological products are used at the appropriate times and the veterinarians often have to spend quite long periods on the ranches at a given time to carry out the various operations.

In the less developed countries, animal health problems are largely the concern of the state veterinary services which are developed and enlarged as the work develops. The essential need for veterinary services is recognized in all these countries and their extension is often limited only by the number of veterinarians available. It can be appreciated that there is an ambition to employ veterinarians trained in the country itself or in the area. This has not always been possible and it has been necessary to appoint veterinarians trained in the better developed countries as personnel of the state veterinary services. This has had its advantages, for it has meant that solid foundations have been laid by well-trained veterinarians and on such foundations it has been possible to build up services which, following expansion, are proving their worth in world economy. As time goes on more facilities are being provided for the local education and training of veterinarians in parts of the world in which less developed countries exist. This, together with the hoped-for improvement in conditions for locally trained veterinarians, will encourage more young people to graduate as veterinarians and will obviate the need to send students from such countries to veterinary schools in the better developed parts of the world for training.

It can be well appreciated that, in these areas, because of the large numbers of livestock scattered over wide areas and the conditions under which they are maintained, all the work on animal health and disease control cannot be carried out by veterinarians. This has resulted in the employment of lay staff who have undergone some training along special lines, working under the supervision of veterinarians. These men are indispensable today and the result of the duties they carry out is reflected in the progress now being made in the improvement of animal health in many parts of the world.

The work of a state veterinary service in the less developed countries must be essentially concerned, in the first place, with the control and prevention of contagious and infectious diseases. Generally speaking, the individual animal is of little consequence; the object of the veterinary activities is to free groups of animals from disease, and to prevent the occurrence of disease in a locality. Thus, large numbers of animals are treated at one time and at appropriate periods and places. Team work is the keynote in such areas. Naturally, the recognized and prevalent diseases are now

and will continue to be given priority in the work of such veterinary services. It is highly encouraging to note the progress, sometimes rapid, that is being made in the control and eradication of some of the diseases which, at one time, were prevalent in such areas. Attention is always being given to diseases which may have been recently introduced or which may have been unnoticed in the past. In this work, veterinarians are greatly assisted by the observations carried out in other parts of the world and by the results of work from diagnosis and research laboratories in the area and elsewhere. Despite the precautions taken to prevent the introduction of new diseases into an area, spread from outside the area sometimes occurs; the early recognition of the infectious agent is essential so that recognized control measures may be brought into force.

There has always been much discussion on the part which veterinarians should play in animal husbandry and nutrition of livestock and, although it may be claimed that animal disease control is a subject apart, there is undoubtedly a close link between them. This is marked in the maintenance and improvement of animal health, especially in the less developed areas of the world, and necessitates a good knowledge of animal husbandry by veterinarians in such localities. This knowledge has to be acquired during the training period as well as by experience. Animal husbandry in all its aspects must be one of the important subjects dealt with at veterinary schools in these parts of the world, where livestock owners depend to a remarkable extent on the discussions with and advice received from veterinarians. It often happens that veterinarians, in the course of their travels in these areas, are consulted on many problems pertaining not only to animals but also to human beings, and it is of interest to record that in at least one veterinary school a short course in human medicine is included in the veterinary course.

As animal production is being improved in the less developed countries, the importation of valuable breeding animals is taking place. While these animals have undergone examination before export and have been found free

from infectious diseases, their further examination on arrival is necessary, in order to minimise any risk of the introduction of any specific infectious condition. Such valuable animals must also receive careful veterinary attention to prevent their acquiring any local disease to which they may be susceptible and immediate treatment, should any such infectious condition be diagnosed in them. Thus, although in general individual animals in the less developed countries do not normally receive much attention, exceptions are made with imported stock.

While the bulk of the veterinary work in these areas is carried out by state veterinary services, veterinarians in private practice are also found, especially in the larger towns. As a country becomes developed and herds and flocks of good quality animals are established, the demands for the services of veterinarians in private practice increase. There is also considerable scope for such veterinarians in racehorse work and in attending to the health and diseases of domestic pets, e.g. dogs and cats.

Diseases, probably less spectacular than those normally found in these less developed areas, are gradually receiving attention, and their control will be increased as more veterinarians become available.

One of the objectives in improving animal production in the less developed areas of the world is to set up export trade in livestock and animal products. In some countries a beginning has already been made in this work and abattoirs under the control of veterinarians are available for dealing with a considerable number of animals. Economically, the health of livestock will play a considerable part in the success of such operations. Control and eradication of the already recognized diseases, research work carried out by governments or by private enterprise on the causes and control of hitherto unrecognized diseases, and the provision of the necessary biological products and medicaments are all essential parts of such schemes. It is encouraging to note that these subjects are recognized and that action is now being taken in some areas to develop all this work to as great an extent as circumstances will allow.

SWAMPWORMS AND TUSSOCK MOUNDS IN THE SWAMPS OF TESO, UGANDA

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In the country lying north of Lake Kyoga (Teso District) there are large areas of seasonal grass swamps which, during the dry season, are used for cattle grazing. In some of these swamps the ground is raised into a large number of closely placed mounds which very much reduce the value of the land for grazing (Harker 1955). Harker, recommends that the earthworms which supposedly build these mounds should be studied with a view to eliminating them.

In their report on the water resources of Uganda, Sir Alexander Gibb and Partners (Gibb 1955) suggest that in certain areas the mounds should be levelled to fit the land for rice cultivation. Gibb and Harker both assumed that the mounds have been built by earthworms without establishing this as a fact. Since the fertility of the soil in temperate climates is much enhanced by the activities of earthworms, it is clear that more basic information is required concerning the origin of these mounds and of their composition before action can be taken to improve the land for crops or pasture. It is our object to provide some of that information.

This work is part of a scheme of research on Tropical Swamps based on the Departments of Zoology and Botany, Makerere College and financed by the Nuffield Foundation. One of us (D.P.S.W.) was assisted by the Makerere College Research Grants Committee.

THE TUSSOCK MOUNDS AND THEIR MODE OF FORMATION

The size and shape of these vary within wide limits. Of the 26 so far measured, the height varied from 25 cm. to 60 cm. In general outline, they can be classified into two main groups: cylindrical and rectangular. Of the cylindrical mounds, the diameters at the top vary between 20 cm. and 100 cm., whereas the rectangular ones can be as long as 4 metres with a breadth varying between 40 cm. and 60 cm. The distance between one mound and an adjacent one varies between 10 cm. and 44 cm. In an area of 25 square metres 80 such mounds were counted. It is obvious that cattle would find it difficult to walk about on such ground.

There are three species of worms living in the mounds. The majority belong to a species of the genus *Glyphidrilus* which had never before, so far as we know, been recorded from Uganda. Next to *Glyphidrilus* in order of abundance is *Alma stuhlmanni* and lastly *Alma emini*. These three species were very often recovered from the same mound. These swamp-worms are closely related, being members of the Microchaetinae section of the family Glossoscolecidae.

On a visit during the dry season, dry worm casts of the size usually produced by the two *Alma* spp. and *Glyphidrilus* were seen on the surface of the tussock mounds. In cases where the water level was part-way up the sides of the mounds, there were fresh casts at the water-surface/mound boundary. During the rainy season, when the water was just covering the mounds, the hind ends of the worms were observed protruding from burrows over the water-logged surface of the mounds. (It is a habit of these worms to push their hind ends out of the mud or water, and expose the grooved dorsal surface to the air for respiratory exchange—see Beadle 1933 and 1957.) No worms were observed in the deep water between the mounds.

To discover the fate of the worms in dry conditions, a hole was dug in one of the swamps. The first two worms were found at a depth of 40 cm. and the numbers increased with depth and soil moisture until at 1.5 metres they were very abundant and in a dormant or aestivating condition. It was noticed that they were concentrated under the tussock mounds but that there were none under the surface in the intervening spaces.

Experiments carried out in the laboratory have shown that as the swamp mud in an experimental tank dries up, the worms move down following the water table. When the mud has completely dried, they are quiescent at the bottom of the tank, in which state they have been kept for as long as two months. They become emaciated and shrink to a small size, but when water is then added to the tank they find their way to the surface within 24 hours.

It is clear therefore that the worms found under the mounds during the dry season come up and resume their activities when the swamps are flooded in the rainy season.

Since the worms are confined to the soil below the mounds, the casts produced during the next rainy season will pile up onto the surface of the already existing mounds and not elsewhere. The observed lateral expansion of the tussock mounds would be due to the casting at the earth/water interface during the rising and falling of the water level. The ground between the mounds could be kept free of worms and vegetation by cattle walking between them and by the depth of water during the floods. This, we suggest, is the way in which mounds have been built and are still being built by the three species of Microchætines mentioned above. It is not yet clear what causes the initial concentration of the worms at one point to initiate the building of a mound.

It has been possible, during the dry season, to measure the height of the worm casts produced during the previous rainy season, on the top of the mounds. Sixteen measurements gave a range from 3.5 to 7.0 cm. with a mean of 5.0 cm. While this does not give an absolute rate of growth of the mounds—since some of them were hanging in a state in which they would obviously break during the subsequently wet season—it gives an idea of the amount of casting done in a season.

During the rainy season, when most of the mounds were partially covered to varying levels by water, an attempt was made to count the total number of worms in a mound. The method used involved in the first place measuring the height and diameter of the mound. The whole mound was then removed as quickly as possible by digging with a spade round the edges of its base and moving it bodily onto a large tray. The mud was then carefully sorted out and the number of worms counted. It was confirmed that there were no worms left in the soil immediately below the mound. It was therefore assumed that most of the worms, if not all, were in the mound itself. The results are shown in Table I.

Even if the volumes of the mounds are taken into account, the number per unit volume of the soil varies within wide limits. The greatest number counted per mound was about three times the least number. Though these figures give an idea of the range of variation in density of worm population between one mound

and another, it would obviously be necessary to make counts from a much larger number of mounds to arrive at a reliable figure for the total population of an area. But calculated on the basis of these counts, there would be some 300 worms per square metre at a time when the water level is near the top of the mounds. It is interesting to compare this figure with those given by Svendsen for the total number of Lumbricids obtained from an area of one square metre to a depth of 20 cm. in the Pennine moorland (Great Britain). Four hundred and seventy worms were recovered from mixed alluvial soil, and 389 from soil without raw humus (Svendsen 1957).

TABLE I.—WORM COUNTS IN TESO MOUNDS
(Measurements in centimetres and cubic centimetres)

Mound	Diameter	Height	Volume	Number of Worms	Volume per Worm	Depth of Water
1	20	30	9,420	74	127	20
2	32	31	24,919	67	372	20
3	31	25	20,069	80	251	20
4	31	33	26,527	169	157	20
5	25	28	14,858	118	126	20
6	28	33	20,310	126	161	21
7	28	33	20,310	69	294	25
8	25	35	18,573	59	315	22

GRASS ASSOCIATIONS

In the paper already cited, Dr. Harker gives a list of the predominant grasses in the Teso swamps. When we visited Kajonyi Swamp near Soroti during the dry season in January, *Setaria trinervia* appeared to be the dominant species. It was of interest to find that this species was growing mainly on the tussock mounds, and few were found in the spaces between them. An area of 25 square metres was then cleared of all the tussock mounds in order to observe the subsequent growth of any new mounds.

When this swamp was again visited after six months, and during the rainy season, one striking point was observed: the dominant grass growing in the area which had been previously cleared of mounds was quite different from that dominant on the mounds in the surrounding area. That dominant on the mounds was later identified as *Cyperus haspan* whereas the dominant species in the cleared area was *Echinochloa pyramidalis*. The latter was also found dominant in areas between the mounds. This difference in plant association indicates that differences may exist between the quality

of the soil in the mounds (largely worm casts) and of that in the intervening spaces or the cleared area. Such differences were confirmed by the analyses recorded in the next section.

COMPOSITION OF MOUNDS AND PARENT SOIL

Since earthworm casts are known to have a higher pH, organic matter, moisture content and exchangeable K, Mg and Ca than the surrounding soil (Anon 1950, Griffith 1938, Joachim and Kandiah 1940, Joshi and Kelker 1952, Nye 1955, Shrikhande 1948), chemical analysis should both establish the origin of the mounds and provide information concerning the agricultural value of the soil.

For this purpose samples were taken from two swamps as follows:—

- (i) *Ochuloi Swamp*.—At the time of sampling (10th January, 1958) this was partially flooded when (ii) was quite dry. It was chosen as an example of a swamp which is partly inundated for most if not all the year and to furnish fresh worm casts for analysis. Three samples were taken from each of 25 mounds in the positions shown in Fig. 1.
- (ii) *Kajonyi Swamp*.—This was chosen to show the conditions in the dry season when the water table was more than 150 cm. below the base of the mounds (10th January, 1958, Fig. 2a) and for studying the flooded soil (on 28th May, 1958) in an area 5 × 5 metres from which the mounds had been artificially cleared in the dry season five months previously (Fig. 2b). A single set of samples was taken from each site.

OCHULOI SWAMP

FIG. 1.

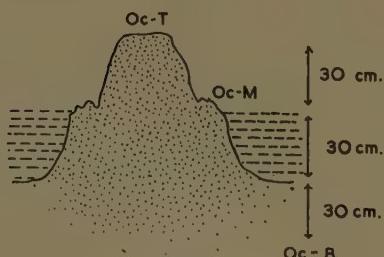


Fig. 1.—Ochuloi Swamp

Oc-T—Top of mound.

Oc-M—Fresh wormcasts.

Oc-B—30 cm. below the surface of the mud between two neighbouring mounds.

The following analyses were done:—

1. Percentage of water by weighing before and after drying at 110° C.
2. After air drying in the laboratory:—
 - A.—Ashing at 800° C.
 - B.—Organic Carbon by the Walkley-Black method.
 - C.—Kjeldahl Nitrogen using a mixed CuSO₄/SeO₂ catalyst (for the C/N ratio the factor $1.33 \times C/N$ was used).
 - D.—After extraction with ammonium acetate (pH 7.0):—
 - (a) Exchangeable K, Na, Ca, with an EEL flame-photometer. Ca was also determined with versenate using ammonium purpurate as indicator.
 - (b) Magnesium, by titration with versenate using Eriochrome Black T as indicator.
 - (c) Iron, colorimetrically with thioglycollic acid.
 - (d) Manganese, colorimetrically as permanganate after treatment with ammonium persulphate and potassium periodate.
 - (e) Aluminium, colorimetrically with ammonium aurine tricarboxylate.

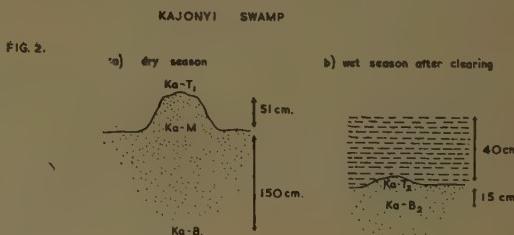


Fig. 2.—Kajonyi Swamp

- (a) **Ka-T₁**—Top of mound.
Ka-M—Middle of mound.
Ka-B₁—150 cm. below the soil level.
- (b) **Ka-T₂**—Top of the cleared area.
Ka-B₂—15 cm. below mud surface.

The results are recorded in Table II, from which the following facts emerge:—

1. The fresh wormcasts from the Ochuloi Swamp (column 2) show higher values than the parent soil (column 3) with respect to all exchangeable ions (except A1), carbon, nitrogen and C/N ratio. Only the ash-content is lower, which indicates a greater percentage of organic material in the casts.

2. The soil at the top of the mounds (column 1) shows a slightly lower concentration of exchangeable ions than the casts, and this is presumably due to leaching. But these values are also higher than those of the original soil.

3. The same situation was found in the dry season mounds of the Kajonyi Swamp (columns 5, 6 and 7). In this case there were no fresh wormcasts and the samples from both top and mid-mound (columns 5 and 6) had been leached. It is to be noted that the differences between top and middle of the dry mounds (columns 5 and 6) were greater than those of the partly inundated mounds (columns 1 and 2). This is presumably due to the fact that under the generally drier conditions in the Kajonyi Swamp the worms less often reach the tops of the mounds.

4. The same tendency was found even in the small submerged mounds in the experimentally cleared area in the Kajonyi Swamp (Fig. 2b). But here the differences between top and bottom soil were less marked, which could perhaps be explained by the short vertical distance between the sampling points and by the difficulty of sampling under water.

SUMMARY AND CONCLUSIONS

It is clear from these observations that the tussock mounds are produced by the casting of swampworms of which three species have been recognized—*Glyphodrilus* sp., *Alma stuhlmanni* and *Alma emini*. It is not explained why the casting should be localized to form mounds rather than spread uniformly over the surface. Once mounds have been started it is clear how the seasonal rising and falling of

water level would cause their growth. We should suspect that the formation and growth of mounds is encouraged by the trampling of cattle on the ground between them.

The chemical analyses show that the fertility of the soil is improved by the activities of these worms. Unlike the earthworms of temperate countries they cannot however maintain activity in anything but a water-logged soil. Complete drainage if technically possible, would therefore prevent the formation of mounds but would reduce the fertility of the soil. It would seem that the best results might be got from regular levelling between the seasonal floods.



Dry season mounds in Kajonyi Swamp

ACKNOWLEDGMENTS

We wish to thank the staff of the Veterinary Department at Soroti for their assistance, Miss A. C. Tallentire for identifying the grasses and Professor L. C. Beadle for suggesting the problem and for his encouragement during the course of the investigations.

TABLE II

	MEAN OF 25 SAMPLES				SINGLE SAMPLES				MEAN OF 10 SAMPLES		
	1	2	3	4	5	6	7	8	9	10	11
	Oc-T	Oc-M	Oc-B	Incre.	Ka-T ₁	Ka-M	Ka-B ₁	Incre.	Ka-T ₂	Ka-B ₂	Incre.
Water %	5	58	28	+107	7	11	16	-31·3			%
Ash %	81·9	82·4	86·0	-4·2	84·1	85·3	91·8	-7·1	90·0	94·0	-4·3
Carbon %	3·7	2·9	1·7	70·5	1·2	2·1	0·05	4100	1·8	0·3	500
Nitrogen %	0·37	0·28	0·18	55·6	0·14	0·22	0·01	2100	0·17	0·06	1833
C/N	13·5	14·1	12·6	11·9	11·4	12·6	6·0	110	13·8	6·1	126
K-exch.	760	770	550	40·0	590	820	210	290	570	230	148
Na-exch.	450	480	240	100·0	450	520	650	-20	280	310	-9·7
Ca-exch.	1320	1380	870	58·7	440	950	750	26·7	660	700	-5·7
Mg-exch.	280	310	270	14·8	160	220	180	22·2	220	200	10
Fe-exch.	5·7	6·7	5·3	26·4	5·3	16·0	8·0	100	5·3	5·0	6·0
Mn-exch.	37	27	17	58·8	13	27	<10	>170	20	<10	>100
Al-exch.	10·7	9·7	9·7	none	12·0	9·7	17·3	43·9	3·3	1·3	154

All the exchangeable ions are in p.p.m. The increases are calculated for the wormcasts over the parent soil (respectively Oc-M/Oc-B; Ka-M/Ka-B₁; Ka-T₂/Ka-B₂).

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REVIEW

MODERN HUMUS FARMING by Friend Sykes, published by Faber and Faber Ltd., London, 1959, xxiv + 270 pp., 25 illustrations, price 28s.

The title of this book is somewhat misleading since only about half of it deals with humus farming methods. Practically the whole of Part II, about 90 pages, is devoted to the results of humus farming in relation to erosion, earthworms and food quality. Even in Part I, where the farming methods are described, the Author tends to be somewhat discursive. The advantages of humus conservation are now widely recognized, though not always practised on the grounds of economics, so much of what the Author has to say is a repetition of already known facts. The book, however, is to be commended if a wider farming public is thereby made aware of the dangers of a trend towards an ever increasing dependence on artificial aids for crop production and protection.

The practical aspects dealt with are land reclamation, harvesting methods, subsoiling, cultivation, composition of manures, livestock and grazing. A more detailed description of these, possibly at the expense of the more philosophical sections, would make the book of greater value to those interested in applying the methods.

Both the planning of the book and parts of the text are open to criticism. Thus, of the 25

illustrations 16 are of racehorses and only six are farming equipment or implements. One of these, showing a sectional view of ground after subsoiling, is divorced from the text and should appear earlier in the book. The ordinate for the graphs on page 83 should read nitrate and not nitrogen. One or two loose statements also appear in the text. Thus, on page 69 it is said that nineteen twentieths of the crop grown in the hedgerow comes from the atmosphere, so that when this crop decays, 20 times as much bulky material is returned to the soil as came from it. In fact, the decay of the crop means that much less than 20 times is returned. On page 103 it is said that the Sahara Desert fails to grow crops because it lacks nitrogen, phosphorous, potash, etc. A better illustration could have been chosen since lack of rain is another factor. On page 241 it is mentioned that seasonal changes in the availability of phosphorous, potash and nitrate were first noticed at Haughley, whereas such changes have been reported in the literature before this.

The book is very interesting and demonstrates the advantages of humus farming without, however, going into sufficient practical detail. Since so much of the book is taken up with stating, and somewhat overstating, the case for humus farming it is less a technical book than a popular scientific one, and is somewhat expensive at 28s.

H.F.B.

THE SEA WE FISH IN

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Most of us realize that different forms of country such as savannah, swamp and forest, harbour different animals and that they move about or, perhaps, change their behaviour as their climate changes during the year. The same is true for fishes in the sea. Fishermen know that some sorts inhabit coral reefs, whereas others are typically found over sandy bottoms and yet others in open water. But so far as the sea is concerned, little is known of the seasonal changes in the underwater climate off East Africa and of the effects of these changes on the fishes.

There were a few early, scattered hydrographic observations off East Africa but there was no planned attack on the hydrology of the region until that made a few years ago by my colleague, Mr. B. S. Newell, as part of our departmental programme. This valuable work was made especially to help the biologists in our fishery work and Newell's recent departure elsewhere is much regretted. The general account that I give here is a biologist's interpretation, in simple language, of Newell's first hydrographic results (Newell 1957). I think such a simplified account would be of considerable interest to fishermen, amateur and professional but I emphasize that the major hydrographic work was Newell's, not mine, although I have drawn upon some of my own recent simple observations and I must take responsibility for some of the comments below. I have also drawn upon the "Africa Pilot" (1939) for information on weather and currents.

The climate of the sea is dependent upon that of the air and it is useful first to review the seasonal climatic changes off the East African coast. There are two very different monsoons with rains occurring as each changes to the other. The seasons vary slightly from year to year but the general arrangement is as follows.

From April to October we have the south-east monsoon. This is correlated with the SE. trade winds which blow strongly from May to September. At the same time the air temperature drops and is lowest in July and August.

From November to March we have the north-east monsoon. In this season the winds are variable between NE. and NW. and vary considerably in strength; characteristically they

are light but they can be as strong as the winds of the SE. monsoon. The monsoon extends furthest south in January but does not always reach the southernmost parts of Tanganyika. Air temperatures rise quickly when the monsoon starts and then increase slowly by two or three degrees more. The end of the monsoon is the hottest time of the year.

Between March and May there are the heavy, or long rains. The light or short rains fall at the start of the NE. monsoon, usually in November to December although they are erratic.

The above generalizations are well enough known. It is less known that there is least wind around March and April with another quiet spell in the Dar es Salaam and Zanzibar region around October/November. These quiet spells coincide, it will be noticed, with the changes between the monsoons (the rains). We are fortunate here in that true gales are unknown although the winds may achieve 50-60 knots in gusts during squalls: these usually occur at the beginning of the monsoons. And, finally, a comment on cloud which we might suppose would prevent sunshine from warming the sea. In general about half the sky is obscured. South of Zanzibar the amount of cloud does not vary much during the year but is at a minimum in the early SE. monsoon after the heavy rains have finished. At Mombasa and Mogadishu the reverse is true, there being least cloud in the NE. monsoon.

The climate varies in detail from Lindi in the south to Lamu in the north, and slightly from year to year. In addition the wind is affected by land and sea breezes, particularly the latter that develop during the day and in the late afternoon deviate the prevailing monsoon wind, usually to make it more easterly.

These weather conditions directly affect the fisherman and very often directly affect the fishes. However, their indirect effects are more important for, by changing the characteristics of the water and the direction in which the sea currents move, the weather changes the "climate" in which the fishes live.

Nearly all of us fish in what the hydrologist calls surface water. Just as there are now well-known surface currents of sea water moving

side by side in rather predictable directions across the sea so there are others below the surface currents. They are not layered simply one on top of the other, but are comparable to currents of motor traffic moving across, over and under a modern "fly-over" road junction. Surface currents may subside in certain regions and lower currents may upwell. There may be more or less mixing of currents at their boundaries according to circumstances. Although almost all fishing off East Africa is done in surface water its character is influenced not only by the atmospheric climate but by underlying water currents. We now know that good fishing can be had in the water that lies below it, or in the boundary of mixed-up water between the layers.

The surface water here consists of the East African Coastal Current (E.A.C.C.). This is part of the South Equatorial Current that comes across the surface of the Indian Ocean at about the latitude of the northern tip of Madagascar where it splits into two, one branch going northwards, which is the one we are interested in, and one going southwards. The E.A.C.C. flows constantly northwards from the southern boundary of Tanganyika to at least Malindi but it flows at different speeds in the two monsoons, with different temperatures, different chemical composition and different thickness.

In the SE. monsoon the wind helps the E.A.C.C. to flow at its strongest (especially from April to June) attaining 3-4 knots, and to continue right past Kenya to beyond Somaliland where it is complicated by upwelling of cold, deeper water. In the first month or two of the monsoon the water still shows features due to the previous monsoon and which are not typical of the SE. monsoon. These need not be mentioned here except for one, the fact that the salinity of the water (an expression of its saltiness) reaches the lowest value of the year in May. This is because low salinity water is drawn into the South Equatorial Current from the Malayan region in the NE. monsoon and it takes some time to come across the Indian Ocean (see Fig. 1). The salinity of our surface water inshore is further reduced a fraction by the rainy seasons, particularly the heavy rains of March to May, both directly and due to the influence of rivers in spate. But the occurrence of minimum salinity early in the SE. monsoon is due primarily to distant effects of the NE. monsoon.

As the SE. monsoon develops the surface water becomes cooler, until in September it

reaches the minimum average of 77°F. (a month or two after air temperatures reached their minimum). This cooling plus the strong wind at that time causes thorough vertical mixing so that water of the E.A.C.C. has roughly the same temperature and chemical properties from the surface to its boundary with the underlying water. Towards the end of the SE. monsoon the vertical thickness of the E.A.C.C. reaches its greatest, i.e. 60-70 fathoms.

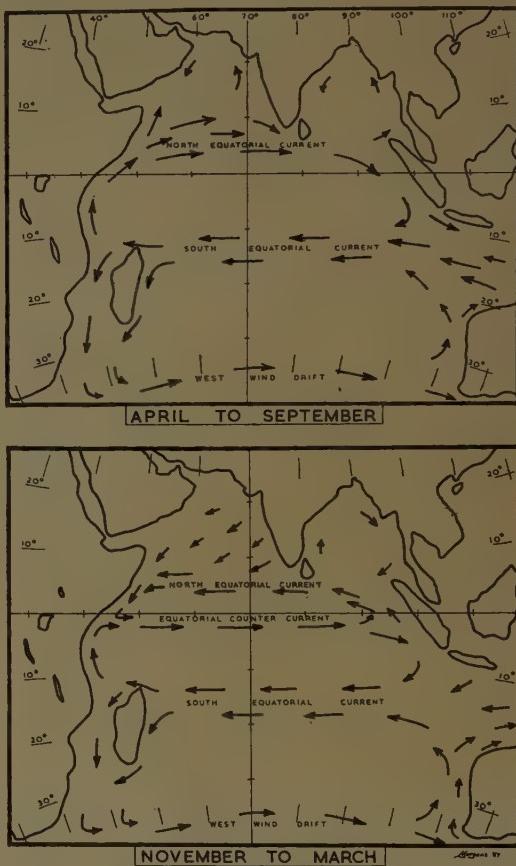


Fig. 1.—Surface currents of the Indian Ocean
(after Newell, 1957)

In the NE. monsoon matters become more complicated. The E.A.C.C. slows down considerably and drops to one or even half a knot in speed during January, February and March. Moreover it cannot penetrate further north than about Lamu where, sometime between December and January, it meets head on a southward flowing current that comes down the Somaliland coast at that time of year. They turn offshore together to go across the Indian Ocean as a composite current named the Equatorial Counter Current; "equatorial"

because it runs approximately along the equator; and "counter" because it runs in the opposite direction to the very important and persistent South Equatorial Current. The meeting point is more southerly in strong NE. monsoons, occasionally off Malindi, and more northerly than Lamu in weak NE. monsoons. The current speeds are not great enough to cause spectacular tide rips where they meet. The Somaliland current dies away about March, i.e., before the SE. monsoon sets in. Although the E.A.C.C. flows along almost the whole coastline of British East Africa in the NE. monsoon, excepting only the area north of Lamu, that small area seems to be particularly interesting in regard to fishery matters, obviously because of the complicated current systems there.

It has been mentioned that distant effects of the NE. monsoon show results off E. Africa in a minimum salinity occurring just after the start of the SE. monsoon. Conversely, the SE. monsoon produces a maximum salinity in the E.A.C.C. during the NE. monsoon, in November to December. This is due to very saline water from the South Pacific having been drawn into the South Equatorial Current.

In the NE. monsoon the surface water temperature rises to the annual maximum average of 84° F. in March (the same month as air temperatures become maximal). In this monsoon the E.A.C.C. itself becomes layered. The three phenomena responsible for this layering are firstly, that the sun warms the surface of the sea; secondly, that warmer water floats on cooler water and so has no tendency to mix downwards; thirdly, that despite this vertical stability, downward mixing is promoted by turbulence of the water, the turbulence being due chiefly to wind and swell.

The generally quiet winds of the NE. monsoon do not promote great turbulence and the sun heats the surface water considerably. This results in a well defined surface skin of warm water, a few feet deep, floating on the main body of the E.A.C.C. water. The demarcation is rather sharp but not absolutely so, and the region where the temperature changes very rapidly with small change in depth is called a thermocline-layer (or thermocline). But turbulence does not remain constant and day to day changes, mixing the warm surface water down to different depths, produce a horizontal layering of the E.A.C.C. so that there is a succession of rather homogeneous layers separated by thermocline-layers (see Fig. 2). The usually low winds and turbulence do not cause mixing to extend deeply and there is a core of E.A.C.C.

water below 10-25 fathoms that is unaffected. However, a few days of strong wind quickly destroys the layering. In the NE. monsoon the vertical thickness of the E.A.C.C. becomes minimal, about 30-50 fathoms.

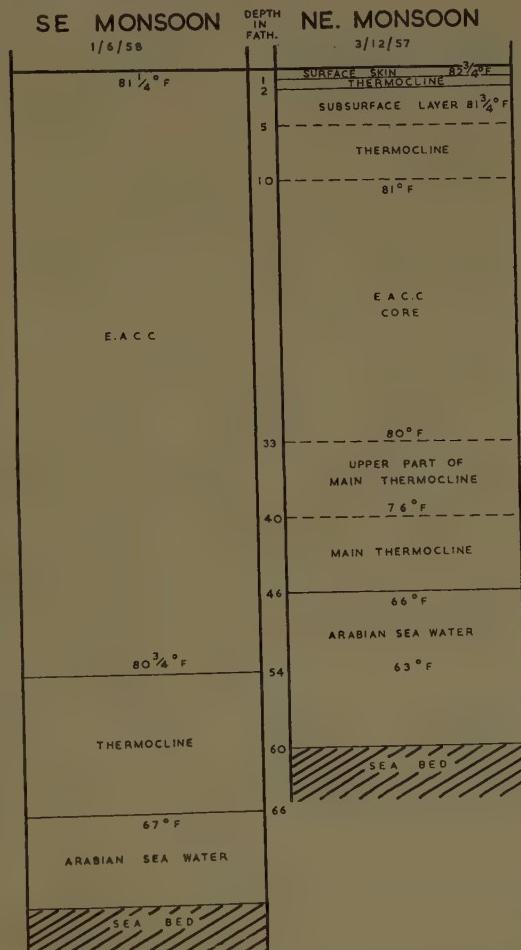


Fig. 2.—Water-layering typical of the Monsoons. (Derived from bathythermograph readings made off Lamu on the dates given.)

Dashed lines are used for boundaries that are poorly defined, solid lines for those sharply defined.

The layering of the NE. monsoon may persist for a while after the start of the SE. monsoon if winds are not strong. With their advent the surface skin and underlying thermocline-layer intermingle with the layer below and progressively the whole thickness of the E.A.C.C. becomes mixed to form the homogeneous layer of almost uniform temperature and salinity that is so typical of the SE. monsoon.

We have considered the layer of water called the E.A. Coastal Current which washes the shores and coral reefs along the coast of British East Africa. This is the water in which most fishermen work whether they are catching Kanadi (Bowrega), or are handling off reefs, or trolling in the open water for sailfish. Inshore, of course, the water becomes considerably modified by tidal action, by warming up in the shallows, by rivers etc., and these effects are beyond the scope of this paper. But what of the water beneath the E.A.C.C.?

Newell has shown that below the E.A.C.C. is a body of water that has moved southwards from the Arabian Sea and at the same time sunk below the surface. The Arabian Sea Water (A.S.W.) has high salinity and, off E. Africa, is colder than the E.A.C.C. and very depleted in oxygen (whereas the E.A.C.C. is rich in oxygen). The speed at which it moves southwards has not been measured but might be in the order of 1 knot.

When a large hydrographic apparatus is lowered on the end of a thin wire on a calm day it is interesting to see the wire go down fairly straight as the ship and apparatus move northwards together on the E.A.C.C.; then, as the apparatus enters the Arabian Sea Water, it quickly moves off southwards so giving the wire a considerable slant. The A.S.W. moves to the south beneath the E.A.C.C. throughout the whole coastline of British East Africa and during both monsoons. It seems to become thickest and most saline in April and May, after the NE. monsoon has helped its movement southward, and a trifle thinner and less saline around Christmas and New Year. A lot more work is necessary to establish the variations with certainty but they appear to be small over the year. The upper boundary of the A.S.W. is very clearly indicated to the hydrologist both by the sharp decrease in water temperature and by the sharp increase in salinity as it is entered through the thermocline-layer between it and the bottom of the E.A.C.C. The bottom of the A.S.W. is poorly distinguished but occurs at about 150 fathoms where it merges with water called Antarctic Intermediate Water (this is of very low salinity but is rich in oxygen; it moves very slowly northwards).

The important points about the A.S.W. are that it differs considerably in temperature, salinity and oxygen-content with the E.A.C.C. water and that it is within reach of any fisherman willing to drop a lengthy line a few miles offshore.

It is worth while to glance again at Fig. 2 and to review the layering of the water. Actual examples are shown of layering found in the two monsoons. They are deduced from bathythermograph traces made off Lamu on my cruises numbered 133 (1-6-58) and 124 (3-12-57). On 1-6-58, in the SE. monsoon, the E.A.C.C. had remarkable uniformity of temperature from its surface to the thermocline and the thermocline was a sharply defined layer. On 3-12-57, in the NE. monsoon, the upper part of the E.A.C.C. was subdivided into surface skin, subsurface layer and E.A.C.C. core, with thermoclines between. In addition it is clear that the lower part of the E.A.C.C. was contaminated by upward-mixing water from the main thermocline (the water of which is, of course, mixed E.A.C.C. and A.S.W.). The temperature of 63° F. at 54 fathoms shows that temperature in the A.S.W. was far from uniform, i.e., it is likely that the core of the Arabian Sea Water was at a greater depth than the sea bed at that locality. In other words, on 3-12-57, there was a clearly defined main thermocline (10° F. temperature drop in 6 fathoms) between the E.A.C.C. and A.S.W. but also layers above and below this main thermocline where each water current contained an appreciable admixture of the other. The presence of a clearly marked core of E.A.C.C. shows that surface turbulence was not causing mixing to extend deeper than 10 fathoms. What caused the mixing on either side of the main thermocline? The explanation is probably twofold. Newell has shown* that internal waves occur here with an amplitude of 5-15 fathoms and that they move the thermoclines up and down several times a day. This turbulence probably mixes the E.A.C.C. and A.S.W. somewhat. Additionally there is probably turbulence arising from friction at the interphase of the two currents since they have different velocities. Further work is necessary to determine fully the extent of mixing of the E.A.C.C. and A.S.W. and to explain it.

The fisherman's interest in the water layering described lies chiefly in the fact that we have found the E.A.C.C. and A.S.W. to harbour, typically, different sorts of fish and that for some species the main thermocline is a potent boundary. More detailed work may prove that fishing is good or bad in the subsidiary layers mentioned. Finally, it is a regrettable necessity to mention that the complicated layering of the E.A.C.C. in the NE. monsoon can often be found in the SE.

* From the manuscript of Newell's second hydrological paper now in press.

monsoon and that the almost homogeneous condition of the E.A.C.C. in the SE. monsoon can often be found in the NE. monsoon. For this everything seems to depend upon the intensity of wind and swell. But the subdivision of fishable water here into E.A.C.C., main thermocline and A.S.W. is invariable and of fundamental importance.

It is not yet possible to give an account of the variation from month to month of the temperatures of the cores of the E.A.C.C. and A.S.W. My own observations show that the core of the E.A.C.C. ranges in temperature from 75-84° F. which is virtually the same range as that at the sea's surface. Maximum core temperature seems to be around April, after which it slowly drops to become minimal around February. The temperature of the top of the A.S.W. is usually around 66-67° F. and perhaps the core is around 60° F.

How do the various hydrographic matters affect fishes? Do fishes stay in one body of water or move around with the changing seasons? Do they, perhaps, change depth? Certainly some have special seasons during which they breed so it is likely that their habits change seasonally. And what of the food supply? Is it constant in quantity; permanently present or transitory? Do fishes change their diet, perhaps, from time to time? These questions must be answered to put fisheries on a sound basis and the underwater climate is of fundamental importance.

Hydrographic matters such as those that have been mentioned are large-scale in their operation, i.e. they do not help us to understand why one can catch many fish on a certain coral patch one day and catch nothing there the next. But persistent small-scale hydrographic work with correlated fishing and biological work will slowly elucidate this everyday fishing problem.

On the large scale, the fact that our coastal water has crossed the Indian Ocean explains why so many species here are the same as are found in the Malayan archipelago and southern Pacific. Combined with other hydrographical knowledge it accounts for the almost complete dissimilarity of our fishes to those on the western side of Africa, in the Atlantic. The Somaliland current might account for the interesting occurrence of a fish off Lamu, but not more southerly, that is probably identical to one of commercial importance which is trawled in great numbers just south of India.

The species, a rock-cod, seems to be distributed across the northern Indian Ocean and extending down the African coast to Lamu where it can be caught in fair numbers.

Our records show that seasonal changes of the E.A.C.C. certainly affect the breeding of many species and are linked with migrations from place to place of some, e.g., the dorade or dolphin fish (Williams and Newell, 1957), and of Kanadi or Bowrega. The migration of the latter species may be from deep water to shallow and vice versa. Again, seasonal changes certainly cause markings on the scales of some species of fish from which their ages can be deduced but, unfortunately, this is not very easily decipherable with tropical fishes. The "aging" of fishes is valuable in finding which years were prolific so as to predict good and bad fishing years (and to legislate accordingly) and is essential for calculating the economical production of a fishery.

Our work, especially off Lamu, has shown very clearly that the E.A. Coastal Current and the Arabian Sea Water beneath it are typically inhabited by different sorts of fish and that they are potentially of great value in both layers. It seems that other species roam heedlessly from one side of the main thermocline to the other. The bathythermograph is an instrument that shows quickly at what depths the thermoclines are found but we can now guess accurately whether we are fishing above or below the main thermocline (between the E.A.C.C. and the Arabian Sea Water) from the sorts of fishes coming up on our hooks. If one is concerned with catching "bottom-fish" then changes in the depth of the thermocline, coupled with the topography of the bottom, will considerably affect where fishes of a certain type will be found, for banks and knolls at 40-60 fathoms may be washed by E.A.C.C. water or by A.S.W. at different seasons. Knowledge of the depth of the thermocline thus helps to position a fishing boat over the wanted fishes.

The importance of hydrological knowledge to fisheries work is established. There are important aspects of it not mentioned above and Newell has a second hydrological paper in Press of which perhaps the most important section deals with the seasonal plant-plankton cycle. Newell has found that "an outburst of plankton growth commences during the NE. monsoon, the actual time of commencement being dependent on the severity of the preceding SE. monsoon. This plankton outburst

appears to reach its maximum in about March and declines through May. From June to September the coastal waters appear to possess their minimum fertility of the year."* Plankton converts chemical salts in the sea into living material (as grass converts the chemical salts in the soil) and so is the start of marine food "chains". Tropical sea-water has a poor supply of suitable chemicals and this limits the quantity of plankton that can grow. We may, therefore, expect the proliferation and diminution of what plankton there is here to be of relatively great importance but so far this has not been demonstrated.

Newell's hydrological work has given the biologists here, and all fishermen, much food for thought. The biologists are eager to present plenty of problems to his successor.

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* Quoted from manuscript. This phenomenon was mentioned by Newell in the paper by Williams and Newell (1957).

REVIEWS IN BRIEF

SOIL AND LAND-USE SURVEYS by the Regional Research Centre of the British Caribbean. Obtainable from the Imperial College of Tropical Agriculture, Trinidad, B.W.I., 3, St. Vincent, by J. P. Watson, J. Spector and T. A. Jones, 70 pp. and map, price 25s.

As with the first two surveys in this series this report summarizes the climate, geology, ecology and agricultural practices, with detailed descriptions of the soil genesis and profile characteristics, soil classification, land use, physical properties, and trace element status and micro-biological analyses of the St. Vincent soils.

SOIL SURVEY AND LAND CLASSIFICATION AS APPLIED TO RECLAMATION OF SEA BOTTOM LAND IN THE NETHERLANDS by H. Smits and A. J. Wiggers, published by International Institute for Land Reclamation

and Improvement, Wageningen, Holland, pp. 60, 15 fig., price \$1.

This is concerned with the reclamation of soils which have been under water. It will be of considerable interest to those concerned with similar problems, such as the reclamation of large areas of marsh.

PLANTATION CROPS, a Review of the intelligence branch of the Commonwealth Economic Committee, H.M.S.O., London, pp. 178, price 5s.

This is a survey of production, trade, consumption and prices relating to sugar, tea, coffee, cocoa, spices, tobacco and rubber. In addition it contains notes on International agreements relating to sugar, tea and rubber as well as Government measures affecting Plantation Crops in certain countries.

THE EARLY HISTORY OF THE KENYA DEPARTMENT OF AGRICULTURE

By M. E. Luckham, Department of Agriculture, Kenya

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INTRODUCTION

The first report (1897) [1] by the Commissioner and Consul-General of British East Africa (Sir. A. Hardinge) lists the departments included in the Civil Administration. There are eight, but Agriculture is not one of them and it is stated elsewhere in the report that "officials, missionaries and railway employees still largely outnumber the traders or agricultural settlers".

In 1901, however, Sir Charles Eliot, H.M. Commissioner, devotes considerable attention to the possibilities of production in his report on the Protectorate [2]. He suggests, for instance, that in the coastal strip "... valuable tropical products might be cultivated ... such as cinnamon, cardamons, cocoa and vanilla ... Ceara rubber trees also thrive and the analogy of German East Africa makes it probable that sisal fibre and ramie (or China grass) could be successfully cultivated". He goes on "the highlands of Ukamba offer favourable conditions for ... European fruits, cereals and vegetables ... though attention is required to prevent over luxuriance" and he cites the case of Brussel sprouts 6 ft. high. Other promising exports are castor oil and fibre (from various kinds of aloes) and it is thought possible that tea, coffee, cotton and tobacco would thrive in Ukamba. The wide plains seem to offer admirable pasture grounds, but it has already been found that cattle from the Coast and Somaliland generally die. He comments "a judicious crossing of native cattle with imported animals would probably result in the discovery of a satisfactory breed." After dealing with the possibilities of developing an india-rubber industry (with latex obtained from *Landolphia kirkii* and *L. Florida*) and pointing to the efforts of the Germans in developing German East Africa, he says "It is not to be expected or desired that our Government should expend on this Protectorate anything like the sum annually devoted by Germany to her East African territories, but it is much to be wished that some practical steps should be taken to investigate and utilize the undoubted wealth of our share of East

Africa. The first necessity is to appoint a rudimentary Woods and Forests Department, which would examine the resources of the country and offer advice on such questions as the best means of preserving rubber and mangrove trees and the probabilities of success in cultivating coffee tea, tobacco and vanilla." Elsewhere, in dealing with the administration of the Protectorate, he sums up as follows: "It will be seen from the above account that the organization of the East African Protectorate is still in its infancy. We have only occupied it for six years; in that time we have built a railway and established an Administration, but the personnel of the latter and the police force at its disposal are so small that we are obliged to depend largely on the military element, and continually call in the assistance of the troops. Also we have not yet had leisure to investigate the products and develop the industries of the country. There is no Department of Trade, Agriculture, Mines or Forests and little has been done to stimulate immigration. The regulations under which land can be held are not yet settled, but are under consideration."

His advice was apparently taken, as his next report [3] (that for 1902-03) ends with the words "When Mr. Chamberlain was here he expressed the opinion that the future prosperity of the Protectorate might be found to lie in the export of wheat and wool and that it would be good economy to establish an Agricultural Department on a larger scale than now exists, for the purpose of making experiments as to the varieties of seeds and animals most likely to thrive, and the methods of irrigation most suitable to the country. Private enterprise can do, and is doing, something in such matters, but experiments in livestock and irrigation can only be conducted on a very moderate scale unless they are undertaken by the Government or by capitalists. I trust, therefore, that in view of the really great possibilities offered for raising stock and growing corn, His Majesty's Government may see their way to assist the establishment of these industries."

(It is of interest to note that by this time there were 15 departments, now including Trade and Customs, Agriculture, Forestry and Veterinary. The Director of Agriculture was Mr. Alexander Whyte, temporarily transferred from Uganda.)

In the section of his report devoted to Products and Trade, Sir Charles again refers to the rubber industry, "already a considerable export", but comments "until responsible firms take up concessions, the Government are not anxious to stimulate the rubber trade, as native collectors do most serious damage by their reckless and wasteful methods of tapping".

Rice, maize and various native grains are stated to be "very abundant". Maize is very cheap (3d. for six pounds) and he regrets that no merchant seems ready to take the opportunity of exporting it at a profit to South Africa.

He again stresses the possibilities of tobacco and cotton in the lowlands "particularly if they are undertaken by firms who are able to prosecute them on a large scale". Tobacco was already being grown at Gazi, south of Mombasa, and the results obtained were said to be satisfactory. A leaf of superior quality was also reported to have been grown near Lamu by a German firm some years before. More is known about cotton: "an indigenous variety grows freely in Tanaland and Gosha, and the natives makes a rough but quite serviceable stuff from it. Also about ten years ago a German firm experimented with imported seeds near Lamu". The quality of the seeds used were not known (it sounds as if he meant "origin"), but the reports they sent to Liverpool, Naples and Germany were preserved and were "most satisfactory". The samples were classified as "resembling lower-quality Sea Island" and "between Tahiti and Sea Island" and priced at 7d. to 9d. per lb. Sir Charles concludes: "It is greatly to be desired that an expert should visit the Protectorate and give the commercial world an authoritative report on the prospects of this important industry".

In passing he mentions that "Mr. Whyte (the Director of Agriculture) also reports [4] that *Indigofera arrecta* is indigenous and abundant on the coast. This is said to be the richest of indigo-yielding plants, and the only one which can compete commercially with artificial dyes at the present time".

In the highlands, the chief indigenous vegetable products which have a commercial value are stated to be rubber, fibre and castor oil beans. With regard to rubber, however (*Landolphia* was known to grow on the Nandi escarpment) he says that less is known than for the coast and that it is probable that the plant prefers hot tropical forests. For castor oil beans a local value of £2 10s. a ton and a United Kingdom value of £8 5s. to £9 10s. is quoted. Various fibres are stated to be abundant and to have been well reported upon both for length of staple and quality. The value in England is said to be from £11 to £13 a ton.

He goes on: "The success which has attended the cultivation of introduced plants is remarkable. Almost every sort of European vegetable and fruit can be grown in good quality and quantity. An export trade in potatoes to the Cape is beginning, and when once the transport has been properly organized practically unlimited supplies can be sent. East African potatoes realized at Lourenco Marques and Durban £11 a ton, which gives a profit of nearly £3 per ton to the grower and middleman. The demand appears to be considerable. Grain has unfortunately never been grown on a large scale, but some small experiments have been made. Barley sent to London was valued at 32s. a quarter, and wheat grown near Nairobi was classed on a par with Australian wheat".

Coffee, from seed introduced from British Central Africa, was being grown in Kikuyu in two plantations, one of which had been established for five years and the other just over three, and was flourishing. Sunflowers were also doing very well and, it was thought, would be a paying industry; silk was being tried in the Kenya (now Central) Province, where Japanese mulberries thrived. The enormous grazing areas and large herds of native cattle and sheep are referred to; only a few European cattle had so far been introduced by private persons, but it was anticipated that the potentialities of the Protectorate as a grazing country would be utilized before long and that wool would form one of the principal exports.

An appendix to the report gives comparative tables of the principal imports and exports for the years 1899 to 1903. It is stated that exports are from the East Africa Protectorate and in the case of ivory, rubber, hides, horns, etc., figures for Uganda are given separately. The bulk of the export table is given overleaf. (The original shows values in rupees also.)

THE BEGINNINGS: 1903-07

The years 1903-04 saw the newly-appointed Director of Agriculture (a Mr. Andrew Linton of whom nothing is known other than his name and the reports he wrote) busy on surveys of the various parts of the Protectorate. He reported first [5] on the district between Voi and Kiu. In the light of the subsequent course of events his remarks on this district as it then was are of considerable interest. A few uncultivated cotton plants were found growing near Voi, so well that it was thought that cotton could become a useful crop in the district. Sansevieria, too, grew abundantly and seemed a possibility as an economic crop. In Mwatate district good maize (from American seed imported some eight years before), sugar cane and bananas were grown, also beans and the "shrub pea" (*Cajanus indicus*) and small areas of cassava, sweet potatoes and tobacco. The fertility of the soil and the wonderful climate of Bura Mission (in the Taita Hills) is remarked upon. At the mission coffee, oranges, figs, pomegranates, mangoes and guavas all produced well. Striking north from Mwatate to Mbale, he was much struck by "the wonderful Wateita hill cultivation" and their system of irrigation. He thought them more enterprising than the Wakikuyu and that they could be induced to grow cotton. He writes "The Wateita, with a little help, will be able fully to develop their own lands and their rights should be closely preserved in case of any settlers applying for land already wholly or partly occupied by the natives." (At that time it was thought that the district between Voi and Kiu would appeal more to the European than the colder districts further up-country.) Among others, the following conclusions were reached: (1) The Voi swamp, if drained and irrigated, would grow cotton, maize, and other crops and would be suitable for European and Indian settlement. (2) The country around Makindu was also considered suitable for settlement and stock. (3) A small agricultural station should be started at Sultan Hamud to test the possibility of growing crops without irrigation and to get into touch with the natives for the purpose of buying their produce and improving the seed of their crops. (4) There should be another larger station at Makindu to experiment with cotton growing under irrigation and with date palms.

The second report, covering the Rift Valley from Kijabe to Nakuru and Njoro recommends the lower areas for stock ranching and the Mau Plateau with its richer soil and

heavier rainfall for mixed farming. The danger to crops of "sleet-like" storms is mentioned. In the Rift the best lands for settlers are considered to be those on the Mbaruk River and south of Lake Nakuru, both districts being well supplied with water and capable of development. Mau farms, it was thought, should carry three sheep to the acre. Ordinary crops and vegetables would grow well and the rainfall would usually permit of continual cropping at all seasons.

The third report was on the country between Tsavo, Taveta and Voi. The whole Tsavo Plateau, it was considered, was a place for the capitalist rather than the ordinary settler, but it was a locality of great promise, suitable for irrigation and for growing cotton, fibres, rubber, maize, beans and sugar cane. The Wataveta, it was observed, had splendid soil and abundant water, but a very unhealthy climate, and were not industrious.

The fourth report dealt with Southern Mau, Lumbwa, Nandi and Kibos. Oddly enough Kericho is not considered as a possible tea-growing area, although the Nandi and Lumbwa country is (and also for coffee and fibre plants), but this may have been due to the absence of labour, which is remarked upon, and the distance from the railway. In Southern Kavirondo it is observed that the natives keep a fair head of cattle, but are mainly cultivators, millet being practically their only crop. The country should be suitable for cotton. At the end of the report the Director states that his "assistant will spend some time going through the fields instructing the natives how to plant cotton and other crops to ascertain the possibilities of the country. Nandi and Lumbwa will be supplied with a little maize seed, and with the help of district officers small experimental stations will be started at Mumias, Nandi and Kericho."

No. 5 (May, 1904) was on the Machakos district. It is observed that both Europeans and natives cultivate the hills rather than the plains, although the plains soil, though variable, is generally richer. The plains however have many defects: lack of natural drainage, unhealthy for stock, mainly because of the abundance of ticks, and the difficulty of building owing to lack of trees. It is considered however that they are admirably suited to the cultivation of cereals. Farms should be part hill and part plain. The land would probably carry two sheep per acre. To the north of Machakos the hills are densely populated with Wakamba who are keen cultivators, growing

a variety of crops. They do a little hill irrigation. Indians near Machakos grow onions successfully, but the bulbs are relatively small. For settlement a moderate area of fair land in the basin at the foot of the hills surrounding Machakos is suggested. Small experiment stations had been started both at Machakos and Mwatate, mainly to test the possibilities of cotton growing. It was also hoped to show the natives the use of manure and the benefits of rotation of crops. It was intended to extend and strengthen these stations but not much could be done without European supervision. At Kiu and Voi Indians had planted a fair amount of cotton, but it was interplanted with beans and maize and hadn't a fair chance. A little seed was sown in the orthodox style and results were awaited.

The sixth and last report of this series (June, 1904) covers the Kenya district, now known as Central Province. "In few other parts of the Protectorate", writes the Director of the Fort Hall district, "are soil, water, labour and climate so favourable to successful agriculture. It is noted that the Wakikuyu near Fort Hall are very regular cultivators, the crops usually being planted unmixed in straight rows, which was very uncommon. Crops are bananas, yams, sweet potatoes, colocasia, vegetable marrow, millet, *Pennisetum spicatum*, eleusine, sugar cane, tobacco and a little cassava. Various beans, maize, pigeon peas and *Phaseolus vulgaris* were rapidly becoming important crops. Rope was made from various fibres including sansevieria, several hibiscus, banana, *Ficus*, *Triumfetta*, *Abutilon* and *Dombeya* species, and *Raphia*. Indian cotton in the Sub-Commissioner's garden produced a luxuriant crop and it was thought that cotton might grow on the plains though it would probably need irrigation. At Nyeri wheat, barley and maize grew well and nowhere in the Protectorate were there such good vegetables. It was thought that coffee, ramie, flax, banana fibre and cereals could certainly be grown with success. The grazing lands beyond Nyeri were some of the richest in the country. It is observed: "From 1,500 ft. above Nyeri to the Laikipia Plateau is rough moorland. Valuable as the collecting basin of a great many rivers, and well covered with vegetation, it regulates the water supply to the lower country. In droughts it would be a standby for grazing. It should be reserved on this account and for its scattered forest." The Laikipia Plain, above Naivasha, was considered to be a most val-

able grazing ground. It was then grazed by Masai flocks and enormous herds of game.

Except for the first, these reports all appeared as annexures to the Commissioner's report [6] and matters later to be covered in departmental annual reports are all dealt with in that report. The Commissioner states "The most striking features (of the year under review) . . . are the influx of European settlers into Kikuyu, the Rift Valley and Mau Highlands and the growing prosperity of Kisumu and Kenya Provinces (this is principally a development of native trade)". Exports of rubber had increased by 38.4 per cent, of hides by 80.6 per cent. Exports of potatoes had increased in value from £300 in 1902-03 to £2,852 in 1903-04, but a note of warning is sounded: "in an endeavour to exploit the South African market, the export trade was spoilt through bad handling, careless selection and general lack of experience. It may be recovered, but settlers should not put all their money into this crop." Great attention was being paid to cotton, but it was still in the experimental stage. The best crops were believed to be those at Kibos, where some 75 acres were under cultivation. Samples were examined by the British Cotton Growing Association and priced at 5½d.-6d. a lb. The seed was Egyptian. In 1904 a cotton expert was appointed to find out the most suitable varieties of cotton to grow at the Coast and to encourage cotton growing by Africans. He reported [7] that cotton could be successfully grown throughout the watered coast belt, in the Vanga, Malindi and Lamu districts and inland around Voi, Taveta and Tsavo and in the Lake (Nyanza) district. In this year a crop of 36 cwt. from the Malindi farm sold in the United Kingdom at prices ranging from 5½d.-7½d. a lb. and was reported on as "clean, good colour, staple a little irregular but strong, and a good result". A very heavy crop was also obtained from Kibos, but the quality was not of the best. In all 25 tons were exported. In 1905-06 exports rose to 80 tons, the Malindi farm producing a crop of four tons, selling for prices up to 8d. a lb. A settler in the neighbourhood realized even better prices. Egyptian seed of the Abbasi variety gave the best results; Sea Island, though giving a longer staple, was too delicate to thrive well. It was hoped that by the following year there would be some 1,200 acres of cotton in the district. In 1904 the British Cotton Growing Association had kindly presented the Protectorate with some cotton seed, gins, and a baling press, and

in 1906 showed further interest beginning experimental work in April, and a large ginnery was erected at Malindi. The first two seasons were promising, but when the rains failed in 1907, 1908 and 1909 cotton planting at the Coast faded away on a large scale. The crop continued to be grown in a few favoured areas and under irrigation, especially along the banks of the Tana and Juba rivers, heavy yields of good quality cotton being obtained.

Reverting now to the Commissioner's report, he has this to say about the work of the Department: "During the year under review the efforts of the newly established Agricultural Department have been mainly directed towards the establishment of two experimental farms, one at Nairobi and one at Naivasha, and to that examination of the country . . . to ascertain the relative suitability of the various districts for agriculture and stock raising". (The resulting reports on the districts are dealt with above; reports on the experimental farms for the year 1904 appeared later [8].) The object of the Nairobi farm was stated by the Director to be "to demonstrate to enquirers and experts that certain crops will succeed, seeds and young plants will be distributed from the farm, a few stud animals will be kept, and a small herd of stock." With regard to these farms, the Commissioner comments: "It is unfortunate that the first season during which agricultural experiments have been made should have been an abnormally dry one, a fact which has largely contributed to the partial non-success met with in the production of certain crops, and which has made us chary of accepting the results of many experiments as final. Maize, millet, wheat, barley, lentils, fenugreek, linseed and native beans have been pre-eminently successful; cotton, clover, ryegrass, lucerne and Egyptian cotton moderately so. English wheat has made little headway and oats have grown perhaps too luxuriantly. The crop of potatoes, which are extensively cultivated by the white settler, has been poor everywhere; but two crops a year can be produced and Mr. Linton, the Director of Agriculture, is of the opinion that in an ordinary season a profit of at least £2 per acre should be realized on each crop. At present, however, the market is uncertain and transport expensive. The freedom from this latter disability enjoyed by such products as cotton, coffee, rubber and fibres should obtain for them a prominent position in the agriculture of the country."

With regard to stock (Naivasha was from the first a stock farm and at that time included a zebra ranch, but this was not a success and was closed down the following year), he remarks: "Competent judges appear to agree in thinking that parts of East Africa possess infinite possibilities as a stock-raising country . . . To develop this industry, it will be necessary either to introduce fresh stock or to improve the native breed by crossing. If the former method is adopted there is the risk of incurring total loss, owing to the disease so prevalent in the country; though the unlucky losses which have been sustained among the pure-bred imported stocks in the experimental farm can in no instance be definitely attributed to conditions prevalent in East Africa. (The station lost 38 out of 120 head of cattle, sheep, pigs, goats and a stallion donkey, which was one of the casualties (accident).) Cross-bred English and native stock will prove more immune from disease than either of the parent breeds; cross-bred cattle are, even in the first generation, a great improvement on the native breed, but it is estimated that it will take five or six generations of cross-breeding to get a woolbearing sheep of the proper merino type. Guernsey cattle and Lincoln and Welsh sheep appear to do best; poultry and pigs also do well." He concludes: "There is a germ of great value to the country in the work of the Agricultural Department, the duty of which is to obtain experience for the farmers at Government expense; no doubt this ideal has not yet been fully realized, but the organization and establishment of the Department on an efficient footing must necessarily take time."

By the end of the following year there were four experimental farms (Nairobi, Mazeras, Makindu and Malindi) and full reports on these, signed by the writers, appear as appendices to the Commissioner's report for 1905-06 [9]. The Nairobi farm again had an unsatisfactory year and it was remarked that the soil of the farm was on the whole poor, with much rock near the surface. It was not well situated and not characteristic of that part of the Nairobi and Kiambu districts occupied by the settlers and it was hoped to change the site. The following year however was a better one and results were satisfactory on the whole though the wheat trials failed due to the depredations of caterpillars. (This brought forth a proposal to appoint an entomologist and one was in fact appointed in May, 1908. This was Mr. T. J. ("Bug") Anderson.) The

study of manures suitable to the soil was considered of primary importance. At Mazeras the most important experiments made were with cotton from Egyptian seed, rubber, fibre plants and mountain rice. By the following year cocoa, coffee and tobacco were also included, all apparently showing the most encouraging results. It was decided that the site should be moved nearer the railway line.

The Makindu farm was closed on 31st March, 1906. Although this was the only report on it, trial plots had been in existence earlier than 1905, but the locality was unhealthy in the wet season and it did not answer the purpose for which it had been established, namely to attract Europeans and Indians to the plains about 200 miles from the coast. Cotton did well here, but "the natives of the neighbouring hills confined their interest in the farm to raiding most of the livestock."

Malindi was a cotton station from the start and the early experiments with Egyptian seed produced gratifying results, 400 lb. of seed yielding 7,444 lb. of seed cotton of good, fine, long-staple quality.

By 1906-07 a departmental cotton station had also been established at Kibos. There was already an Indian settlement there which, said the Commissioner in his 1905-06 report, could be regarded as a semi-government institution, and had made satisfactory progress. In that year the cultivated acreage increased from 300 to 500 acres, the most successful crops being sugar cane, from which jaggery was manufactured; maize, which the cultivators ground in water mills they had themselves erected, and sold at a good profit in Kisumu; gram and lentils, mostly sold in the grain; and cotton, which was an excellent crop as far as labour was concerned, the picking season not clashing with the time when the Africans were working in their own plantations. Experimental crops of long-eared Egyptian wheat and oats were grown with good results and stock also did well.

During the next two or three years general development continued on the lines already indicated in the Commissioner's reports. Acreages for the principal European crops had been given in that for 1904-05 [10] as follows:—

Maize	..	..	800 acres
Beans	..	..	700 acres
Potatoes	..	..	700 acres
Millet	..	..	300 acres
Wheat	..	..	150 acres
China grass (ramie)		..	90 acres
Coffee	..	..	80 acres
Oats, castor oil, lucerne barley, linseed	..	..	180 acres

Average prices for the principal products were:—

Wheat (per bushel)	..	..	6s. 8d.
Potatoes (per cwt.)	..	..	5s. 0d.
Millet (per cwt.)	..	..	2s. 0d.
Maize (per cwt.)	..	..	4s. 0d.
Beans (per cwt.)	..	..	2s. 6d.

It was noted that the area under coffee was rapidly increasing and that "this product bids fair to be one of the most important in the Protectorate. So far the plants have suffered from no serious disease,"* and the yield has been heavy. One tree produced from 2-3 lb. of dried berries, valued at 6d. or 7d. per lb. f.o.b. London. The great danger is that the trees will over-produce themselves and become exhausted at an early age."

Of the cereals, wheat gave trouble, failing everywhere in 1905-06 except at Njoro, owing to rust. In 1906-07 however, several varieties "more or less rust-resistant" were introduced with promising results and hopes were expressed [11] that enough wheat could be produced for local needs and even for export. Barley, maize, millet and oats did well, the area under maize having greatly extended by 1907. It was stated that there was an increased demand for it by natives and, its cultivation was being taken up by both settlers and natives. Importation of selected farm seed would bring enhanced returns. Rice was being grown at the Coast. China grass (ramie)

* The unlikelihood of this happy state of affairs continuing was apparently realized, as an Ordinance was enacted in 1904 "restricting the importation of plants and seeds with the object of preventing coffee disease" and another in 1905 restricting the importation of coffee, with a view to preventing coffee leaf diseases. In that year a leaf disease appeared in the coffee plantations of the Roman Catholic Mission at Bura in the Taita Hills and the trees had to be destroyed. Black blight caused by scale appeared in the same year in the coffee plantations near Nairobi, but was immediately stamped out by means of resin compounds.

yielded large profitable crops in the moister districts and under irrigation, though in 1907 it was stated that its cultivation was being limited through the lack of a suitable decorative. This was a difficulty which was to persist over the next 50 years. Of the forage plants lucerne and green oats proved the most satisfactory; ordinary root crops and vegetables were all successful. Although in 1906 farmers were stated to be tending to abandon the production of potatoes and beans because of export costs and going in for coffee and fibres, potato growing for local consumption and export was still a feature on many farms in 1907. In addition to ramie and cotton already mentioned, other fibre plants were being developed. The output of sansevieria made great strides especially at the Afro-American Company's works at Voi and sisal became popular at the Coast. (A number of suckers had been imported in 1902-3 from German East Africa and planted out in the grounds of Government House, Mombasa, and in the Sub-Commissioner's garden at Nairobi. In 1904, the Agricultural Society chartered a dhow for a massive importation of bulbils from this source. Government trial plots were laid out at Nairobi, Makindu and Miritini, which also contained bulbils from St. Vincent, and in 1905 rooted cuttings from these stations were issued to settlers.) Another industry receiving great attention on the Coast belt and round Voi and Kibwezi was Ceara rubber and also coconuts and from 1908-12 rubber and copra were among the most important exports, but the rubber plantations were out of production by the end of the First World War. Increased production elsewhere and the fall in the price of rubber was already indicating a need for caution by 1907. Mention is also made (1907) of efforts to develop cash crop growing by natives, particularly of oil-bearing seeds (sesame, groundnuts, etc.) and cotton.

As far as stock was concerned, imports and experiments continued. Shorthorn, polled Angus, Hereford and Guernsey bulls, English sheep and Angora goats, pigs, ducks "of the Manilla type", turkeys and geese are all mentioned in the 1904-05 report. At the end of 1905 the Uplands of East Africa Syndicate imported 5,000 Merino sheep, from Australia, a major enterprise that was not to be attempted again until the import of 1,300 Corriedale and Romney sheep from New Zealand by the K.F.A. in April this year. In the 1904-05 report it was stated that there were nearly a dozen dairies in the neighbourhood of Nairobi;

milk sold at 2d. a pint, butter at from 1s. 8d. to 2s. a lb. Government maintained a dairy at Naivasha, on the stock farm from which cattle of imported breeds were distributed. By 1906-07 pig breeding was said to be a success in many districts and the Uplands of E.A. Syndicate was about to establish a bacon factory. Hopes were even expressed of an export trade. At this time it was also believed that the domestication and breeding of ostriches would become an important asset, but a change in fashions killed this project a few years later. Although horses and ponies were already being imported from England, South Africa, Somaliland, India and Australia and small breeding studs were being started, mules were considered to be the most serviceable animals both for light agricultural work and for travelling. Considerable numbers were introduced from Somaliland. Donkeys of course were also used, the native breed, which was slow, being improved by crossing with the Muscat. Oxen were used for heavy work. Prices were given as follows (1904-05):—Oxen (untrained) £1 to £3, trained £3 to £5; cows £5 to £10; horses £30 to £50; donkeys, male £3 to £4, female £5 to £6, Muscat £25; sheep and goats 4s. and 8s.; pigs £1; mules £20.

A table showing the principal agricultural imports and exports for the years 1903-04 to 1906-07 is given in the appendix.

Expenditure on the Department rose slowly: in 1903-04 it was stated to be £7,610 16s. 6d. (including the Veterinary Department); in 1904-05 it was £9,169 8s. (plus £2,456 1s. Veterinary Department). The following year it decreased to £6,698 10s. 5d. (plus £2,822 7s. Veterinary), it being stated that the decrease was due to capital expenditure in 1904-05 not recurring in 1905-06. In 1906-07 it rose again to £7,512 1s. 4d. (plus £3,372 6s. 9d. Veterinary).

Personnel rose slowly too. The earliest records so far traced are in the Blue Book for 1905-06. At that time the Department consisted of nine persons: the Director, Andrew Linton, appointed in 1903; three Assistants (two, E. Brand and H. Powell appointed in 1903 and one, J. K. Hill appointed in 1904); four Farm Superintendents (one of whom was appointed in 1902 and the others in 1903) and one Indian Assistant appointed in 1906. The Veterinary Department consisted of the Chief Veterinary Research Officer, R. J. Stordy (appointed in 1898), four Veterinary Officers, two Indian Veterinary Assistants and a Goan clerk. By the following year the Agricultural

Department had been increased by one Farm Superintendent, three clerks and an assistant clerk, and the Veterinary Department by a Deputy Chief Veterinary Officer, a Veterinary Bacteriologist, one Veterinary Officer and a Livestock Inspector. In that year the Director of Agriculture was styled Director of Agriculture and Forestry and it is stated that he took over the office of Conservator of Forests on 27th April, 1905. (This was a most economical arrangement as the salary of £800 as Director of Agriculture was increased by a mere £50, the entire sum being charged to the Agricultural vote.) Edward Battiscombe was appointed Acting Conservator of Forests on 29th April, 1906.

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APPENDIX I—EXPORTS

ARTICLE	1902-3	1901-2	1900-1	1899-1900	1898-99
Rubber	£ 7,778	£ 5,112	£ 10,060	£ 17,382	£ 12,792
Gum copal	1,332	1,439	426	1,890	2,702
Hides, horns	14,185	5,059	6,772	10,225	4,524
Tobacco	838	591	984	845	967
Grain	19,534	22,377	18,297	9,677	5,363
Livestock	6,850	2,173	1,923	5,540	7,779
Mangrove poles	4,443	3,454	2,735	3,596	3,508
Mangrove bark	690	969	999	—	—
Potatoes	300	—	—	—	—
Copra	32,273	5,391	—	—	—
Coffee (Uganda)	280	70	—	—	—
TOTALS	165,060	113,206	89,858	121,686	71,145

APPENDIX II—IMPORTS

	1903-4	1904-5	1905-6	1906-7
Agricultural Implements	£ 638	£ 4,035	£ 12,893	£ 19,104
Livestock	7,025	10,032	23,655	8,842
Grains	57,804	60,875	67,000	67,504
Bags and sacks	—	—	4,518	6,186
Seeds and plants	—	—	586	1,300

EXPORTS

	1903-4	1904-5	1905-6	1906-7
	£	£	£	£
Chillies ..	..	..	..	..
Copra ..	..	..	..	..
Fibre ..	..	..	..	..
Grains ..	..	..	..	..
Gum copal ..	..	..	..	..
Hides and skins ..	..	..	..	..
Livestock ..	..	..	..	..
Mangrove bark ..	..	..	..	..
Mangrove poles ..	..	..	..	..
Potatoes ..	..	..	..	..
Rubber ..	..	..	..	..
Cotton ..	..	..	..	..
Wax ..	..	..	..	..
Wool ..	..	..	..	..
	11,084	9,412	9,413	24,146
		—	272	491
	20,596	20,482	27,087	30,749
	1,274	603	725	1,074
		21,820	16,320	25,792
	2,972	3,622	3,347	2,934
	1,155	2,016	3,290	4,569
	3,786	3,386	6,075	6,267
	2,852	3,471	3,773	5,030
	10,772	21,579	18,929	19,944
		285	1,373	1,427
	184	3,925	5,140	4,376
		—	—	944

NOTE.—Figures for 1906-07 are taken from the Blue Book for that year. Other figures are from the Commissioner's Reports.

REVIEW

FARM MECHANIZATION MANAGEMENT by Claud Culpin, published by Crosby Lockwood and Son Ltd., 1959, 225 pp., 17 diagrams, 45 photographs, price 21s.

Written by the Chief Farm Machinery Adviser to the National Agricultural Advisory Service, this is a companion-volume to Mr. Culpin's "Farm Machinery" which was reviewed on page 178 of the January, 1959, number of this Journal. It is produced for farmers in Britain, which has, by some methods of estimation the world's most highly mechanized agriculture. Although many of the details do not apply here, the main arguments are entirely relevant to East Africa. This small volume will provide stimulating reading for East African farmers and planters, for those who supply and service their equipment and particularly for officers who advise them on farm planning and on agricultural techniques.

A list of the diagrams will indicate well enough the type of problems examined by Mr. Culpin:—

Cost of spraying in relation to acreage sprayed annually.

Seasonal labour need on two types of farm. Estimated useful life of common farm machines in relation to annual use.

Cost of Combine Harvesting (P.T.O., self-propelled and by contract) in relation to annual acreage.

Layout of vegetable packing shed before and after work study.

Seasonal distribution of tractor use on two types of farm.

Comparative costs of operating three small-capacity grain driers.

A method of strip folding using an electric fence.

Some layouts of two-level milking parlours.

The agricultural applications of "work-study" methods, now considered indispensable in industry are well illustrated. For example the tractor mileage which can be saved in the course of a manure spreading operation is certainly worth a little careful thought. The importance of fully loading the increasingly powerful tractors sold in recent years, particularly by working them in the highest suitable gear, is a matter of real importance in Africa, where drivers usually have less mechanical knowledge than in Britain.

This book describes and discusses machines only briefly (but with the assistance of an unusually good set of action photographs) while concentrating on their efficient employment. Mr. Culpin does not avoid difficult subjects; the vexed question of depth of ploughing for instance is well considered. A word of warning about the danger of excessive soil pulverization with rotary implements must be added for East African conditions.

A brief but interesting summary of irrigation costs and returns suggests that even in well-watered Britain there will be a steady increase in this practice. In spite of the small seasonal quantities of water involved (only from 2 to 6 inches per year) the author points out that any substantial increase in irrigation will require storages of surplus river flow in wet weather, a conclusion which applies with greatly added force to our environment of exaggerated seasonal changes.

There is an index and a set of tables for U.K. conditions whose values emphasize the high output per man-day which can be achieved by intensive farming.

This compact book has something of interest for everyone who can think critically about agricultural problems.

H.C.P.

SHARKS OF THE WESTERN INDIAN OCEAN

I—LOXODON MACRORHINUS M. & H.

By J. F. G. Wheeler, East African Marine Fisheries Research Organization, Zanzibar

(Received for publication on 20th July, 1959)

This paper is the first of a series intended to assist in the identification of the sharks of the East African coast, where many different species are caught but very little is known about them. There are some easily recognised forms like the tiger shark, the man-eater and the hammerheads, but the majority are "typical" sharks possessing few distinguishing characters. The difficulties of identification are many. It is seldom possible to make direct comparison between fresh specimens of a variable species or even of specimens of similar appearance which are actually of different species. Far less are there chances of comparing one's own material with the types or with specimens whose descriptions have been published. The literature is scanty to say the least, and the original works are hard to come by. Most of the recorded descriptions are based on single specimens, and as changes in proportion occur with growth these descriptions are often misleading, those of adults not being necessarily applicable to juveniles and vice versa. The size reached at sexual maturity is taken as a general rule to be about the full stature of the species. But growth in the sea is not limited by all the factors that control the size of land animals, and there is, as far as I know, no proof of the cessation of growth after maturity.

Among the sharks maturing at less than one metre there are several species superficially alike, one of which has been identified with *Loxodon macrorhinus*, first described by Müller and Henle in 1841 from a 12-inch foetus of unknown derivation preserved in the Anatomical Museum of Berlin. To the group of genera possessing nictitating membranes and spiracles, Müller and Henle added *Loxodon* characterized by: "Circular pupil. Teeth similar in both jaws, with oblique unserrated edges and an unnotched bulge on the outer side of the base. A middle tooth in the upper jaw only. A minute spiracle close behind the eye. Caudal pits above and below. Upper lobe of the caudal with a single notch". In their description of the species *macrorhinus*, and in the figure illustrating it, the obvious features are the long flat pointed snout with the nostrils equidistant between its tip and the mouth, the

second dorsal fin originating behind the level of the anal fin on a base only half as long as that of the latter, and, particularly from the illustration, the large bulging eyes and the extreme tenuity of the body.

Gunther (1870) examined two "young" specimens, 14 inches long, from the Seychelles Islands, and noted that the pre-oral part of the snout was considerably longer than the width of the mouth and that the nostrils were nearer the mouth than the snout tip. He remarked the very short labial folds round the angle of the mouth and counted 25 teeth in each jaw. In these specimens the first dorsal fin was nearer to the origin of the pectorals than to that of the pectorals, and the second dorsal was very small, only half as long as, and situated behind, the anal fin. The caudal was nearly one-third of the total length.

The specimen identified as *L. macrorhinus* by Klunzinger (1871) from the Red Sea was 370 mm. long, but still carried its umbilical cord. The description opens with: "This species bears a very close resemblance to *Carcharinus acutus* but is not a foetus of it. Such a foetus (i.e. of *C. acutus*) had no spiracle, an upper and a lower middle tooth, a short tail fin . . . ". It is obvious that this specimen, like those previously described, was a foetus probably collected when the parent sharks had been gutted and disposed of.

Garman's specimen from Mauritius, referred to by Fowler (1940), was 433 mm. long—again very young, if not foetal. Fowler quotes the dentition, 25 above and 26 below, and gives a series of fractional proportions, which, like all the previous relative measurements and the "very large eyes", cannot be applied with confidence to fully grown specimens. According to Nicholas Pike (Gudger, 1929), *L. macrorhinus* was known in Mauritius as "Le Chasseur."

MATERIAL

My material consists of two mature male specimens and two females, one non-pregnant and the other pregnant with two foetuses.

The species is not rare in Zanzibar, but it was not recognized as distinct until a critical

examination was made of the percentage proportions of all the small sharks that had been measured and recorded as *Scoliodon* sp.? or *S. acutus*? Then certain anomalies became apparent. The first dorsal fin in most of the records was definitely not as high as its base was long, but in some the reverse was the case and in these the greatest depth of the body was less than that of the majority by 3 or 4 per cent. Smaller differences were noticed among other measurements, but the teeth of a preserved head provided conclusive proof that at least two species had been confused, one of which was identified as *Loxodon* sp. Visits to the Zanzibar market resulted in the collection of a male 780 mm. long on 10th June, 1959, and of a non-pregnant female 810 mm. long on the 25th of the same month. This specimen had large eggs in the ovary and one in the oviduct. An earlier record was of the pregnant female 850 mm. long taken in a trammel net set overnight at about four fathoms in Chwaka Bay on the east side of Zanzibar Island (4th September, 1946). It was noted and measured. Its two foetuses were preserved. A male 905 mm. long, which had been caught on a hand-line off Okuza I. in the South Mafia Channel on 8th November, 1958, was recorded with all measurements and its head was preserved.

In the table appended the proportional measurements of the adult specimens as percentages of their total lengths can be compared with one another and with the percentage measurements of the male and female foetuses. In Fig. 1, A, B, and C, the percentages have been utilized to provide profile outlines of the 780 mm. male, the male foetus (186 mm.) and its 850 mm. mother.

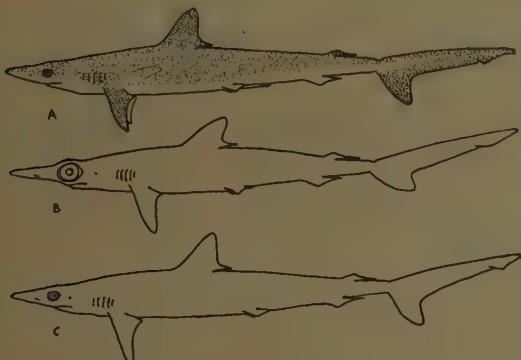


Fig. 1.—*Loxodon macrorhinus* M. and H. Profiles from percentage measurements—A, Male, 780 mm.; B, Male foetus, 186 mm. taken from C, Female, 850 mm.

DESCRIPTION

The colour is steel grey or pale grey or olive grey on the back, extending on the head to below the eyes and gill slits, and on the flanks into the lower half of the body where it fades into white. The backs of the pectorals, both dorsals and the lower lobe of the caudal are rather darker grey than the back of the body. The pelvics are pale grey with a whitish posterior edge and the pectorals may have slightly whitish tips and posterior edges. The leading edge of the first dorsal and the extreme edge of the caudal notch may be very dark. In the post-mortem fresh condition the snout from above appears reddish as far back as the level of the nostrils. It is translucent from below.

The coloration is variable and not in any way distinctive of the species.

The scales are three-keeled as noted by Klunzinger.

The body form is noticeably slimmer than that of the usual run of small sharks, and the snout is longer and thinner. There is no ridge between D I and D II. The eye is much larger relatively in the foetus than in the adult, and in the former the pupil is round.

Many patches of pores open on the snout, the most conspicuous being between and in front of the level of the nostrils and behind the eyes up on to the head. There is a line of pores edging the upper lip and a line on each side above the angle of the mouth (Fig. 2, A). The spiracles are slightly larger than the largest pores, and they are found an eye's length behind the eyes immediately below the post-orbital pores just where the grey colour of the head fades into the white of the underside. I found that on squeezing the skin of the head in these parts the pores readily exuded a colourless mucus, but from the spiracles there was often an effusion of water stained pink with blood. The nictitating membranes can be demonstrated by pressure below the eyes.

In the adult the first dorsal fin (D I) is slightly higher than its base is long, but this is not so in the foetus. Similarly in the adult the origin of D I is nearer the origin of the pectorals, while in the foetus it is nearer the origin of the pelvics as stated by Gunther. There appears to be a certain amount of variation among individuals in the relative position of the fins in addition to the changes due to growth. The small second dorsal (D II) originates at or just behind the level of the rear

end of the base of the anal. In the foetus it is further back than in the adult. In the foetus the caudal fin is equal in length to the distance of D II from the anterior end of D I (Klunzinger), but in the adult it is less by almost the length of the base of D I.

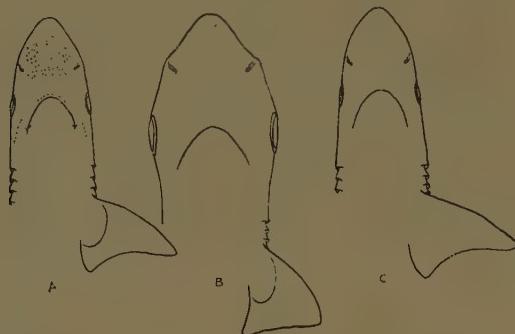


Fig. 2.—*Loxodon macrorhinus* M. and H. Outlines of heads from percentage measurements—A, Male, 780 mm.; B, Male foetus, 186 mm. taken from C, Female, 850 mm.

The labial furrows are confined to the corners of the mouth as shown in Fig. 2, A.

The teeth (Fig. 3, B) are unserrated and the posterior ledge of the base is entire. They are nearly similar in shape in both jaws and very oblique except at the front. There are often teeth of a younger series in effective action with older ones, especially towards the back of the mouth. Among the lower front teeth there can be four effective series (Fig. 3, A). According to Müller and Henle the dentition is 25 above and 26 below. Günther found 25/25. My specimens vary: the 905 mm. male had 27/28, the 810 mm. female 27/24, and the

780 mm. male 25/27, but the front of the lower jaw in this specimen had been damaged and its appearance suggests that the lower teeth numbered 28. There is a middle tooth in the upper jaw and none in the lower (Müller and Henle), so that there should always be an uneven number above and an even number below. It is plain that the dentition varies and may be:—

12—1—12 or 13—1—13

12—12 or 13—13 or 14—14

The diagnostic characters of *Loxodon macrorhinus* are the slim shark-form, the greatest depth of the body being less than 10 per cent of the total length; the presence of nictitating membranes and spiracles; the restricted labial furrows; the unserrated oblique teeth; the position of the small second dorsal fin relative to the larger anal, and the height of the first dorsal relative to the length of its base. The size at sexual maturity suggests that the maximum length attained does not exceed one metre.

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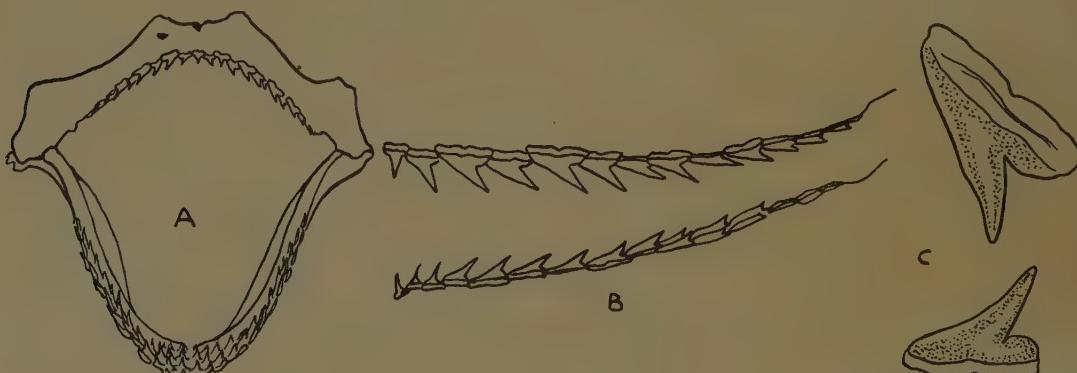


Fig. 3.—*Loxodon macrorhinus* M. and H. A. Jaws with teeth in situ. B. Upper and lower teeth of left side. C. 4th upper and 4th lower tooth from Male specimen 905 mm. long

TABLE I

TOTAL LENGTH	F 850	M 905	M 780	F 810	Adult Averages	F 175	M 186
Snout to line joining ant. ends nostrils..	4·7	4·2	4·4	3·8	4·3	5·1	4·8
Snout to line joining post. ends nostrils ..	5·5	5·0	5·1	4·7	5·1	6·3	5·9
Snout to point of lower jaw ..	8·2	7·8	7·8	7·2	7·8	12·0	11·3
Snout to line joining angles of jaw ..	12·0	10·5	11·0	10·2	10·9	15·4	15·1
Snout to line joining 1st gill slits ..	15·9	14·9	15·0	14·8	15·2	20·6	21·0
Snout to 5th gill slit ..	20·0	20·0	19·6	18·5	19·5	24·0	24·7
Snout to insertion of pectoral ..			19·0	18·1	19·0	23·4	23·1
Snout to axilla of pectoral ..	23·5	21·1	22·4	21·1	22·1	26·9	27·4
Snout to origin D I ..	31·8	30·9	29·6	30·4	30·7	34·9	33·3
Base of D I ..		7·3	7·0	7·3	6·9	7·1	7·5
Free end of D I ..		3·8	3·5	3·5	3·6	2·3	3·8
Height of D I ..		7·9	7·4	7·7	7·6	5·7	6·5
Origin D I to origin D II ..	33·5	33·1	32·8	32·1	32·9	28·0	28·0
Base of D II ..	2·4	2·3	1·9	2·2	2·2	2·3	2·7
Free end D II ..	4·7	4·7	4·5	4·6	4·6	5·1	4·8
Height D II ..	1·4	1·1	1·3	1·2	1·3	0·6	1·1
Origin D II to base C ..	9·6	9·6	10·5	9·9	9·9	10·9	10·2
Dorsal edge C (straight line)	26·5	26·0	26·9	27·2	26·7	29·1	30·1
Base C (dorsal pit) to notch C ..	7·1	7·0	7·2	7·4	7·2	7·4	8·1
Base C (ventral pit) to notch C ..	6·6	7·0	7·2	7·4	7·0	7·4	8·1
Ventral pit to tip of ventral lobe ..	9·6	9·7	10·0	10·4	9·9	8·6	9·1
Snout to insertion of pelvics ..	45·9	43·6	42·3	43·2	44·0	44·6	41·9
Ant. edge of pelvic ..	4·0	4·4	4·1	4·0	4·1	4·0	4·8
Free posterior edge (median) pelvic ..	2·7	1·6	2·4	2·7	2·4	2·3	2·7
Free post. edge pelvic ..	4·7	3·5	3·7	4·4	4·1	4·0	4·3
Snout to origin of A ..	61·2	61·1	57·7	58·4	59·6	57·1	57·5
Base of A ..	4·1	3·9	4·4	4·3	4·2	5·1	4·8
Free end of A ..	4·1	3·9	3·6	3·7	3·8	2·9	3·8
Height of A ..	1·8	1·6	1·7	1·9	1·8	1·7	1·6
Origin A to ventr. pit ..	13·2	12·9	13·5	13·2	13·2	13·7	12·3
Ant. edge of pectoral (straight)	11·1	10·8	10·9	11·1	11·0	10·9	11·3
Greatest width pect.	8·0	6·9	7·1	7·4	7·4	8·0	8·1
Depth of body at D I or greatest ..	9·1	9·4	9·6	10·7	9·8	9·1	9·1
Length of 3rd or longest gill slit ..	2·4	2·3	1·9	1·1	1·9	2·3	2·2
Longitudinal diameter of iris of eye ..	2·4	2·0	2·2	2·1	2·2	5·7	4·8
Longitudinal diameter of eye opening ..	6·5	5·9	6·3	6·1	6·2	9·1	9·1
Distance between ant. ends of nostrils ..	7·4	7·6	7·7	7·4	7·5	13·1	12·9
Width of head at eyes ..	9·2	9·1	8·6	8·4	8·8	12·0	10·8
Width of head at 1st gill slit ..	8·5	8·1	8·6	8·1	8·3	11·4	11·8
Snout to centre of eye ..	5·2	5·0	5·1	5·1	5·1	7·4	7·0
Distance between post. ends of nostrils ..	5·6	5·3	4·9	5·2	5·3	6·9	7·5
Distance between angles of jaw ..	8·4	8·6	8·2	8·0	8·3	12·0	11·8
Width of head at gape ..	41·2	42·5	39·1		40·9		
Origin of pectoral to origin of A ..	15·3	16·9	15·4	14·5	15·5	13·7	13·5
Origin of pelvic to origin of A ..		6·4	6·4				1·6
Claspers (free end) ..				62·4	62·6		
Snout to insertion D II ..				5·5	5·6		
Width across dorsal lobe C at notch ..				3·3	3·3		
Free end of D II to dorsal pit ..					5·3		
Free end A to ventr. pit ..					3·0		
Caudal peduncle (depth)					0·2		
Upper labial furrow ..				0·7	0·7		
Lower labial furrow ..				30·3	30·2		
Snout to point of pectoral laid back ..				24·2	25·9		
Origin of pectoral to origin of pelvic ..				9·0	8·0		
Insertion of A to free end of pelvic ..					4·0		
Base of pectoral ..					0·9		
Ventral pit in advance of dorsal pit ..					27/24		
Teeth ..	27/28	25/27?	27/24			17·7	18·3

SHADE MEASUREMENT BY A CHEMICAL RADIATION METER

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To obtain information as to what extent shade trees affect the yields of crops such as tea, coffee and cocoa, the pattern and extent of the shade must first be determined. This determination requires the distribution of a large number of radiation meters over the area of the plot to be measured. This is only possible if the radiation measuring devices are integrating, cheap and self contained. A tube containing a photo-sensitive chemical is suitable for such measurements, provided that the chemical analysis after exposure to light is simple and that the method gives satisfactory agreement with standard radiation instruments.

Recently, Dore [1] has used a solution of anthracene in benzene as a simple light meter. This method consists of exposing to light, tubes containing the anthracene solution; the anthracene polymerises to insoluble di-anthracene crystals under the action of light and, after filtering off these insoluble crystals, the concentration of anthracene remaining in solution can be determined spectrophotometrically.

The above method was investigated with a view to using it in the field.

SELECTIVITY

With any method of radiation measurement, it is essential to know to what wavelengths the method is sensitive. The selectivity of the anthracene solution was determined by covering over apertures cut in wooden boxes with various light filters, placing tubes of anthracene solution in the boxes, and exposing them to sunlight. The filters had previously been placed in a spectrophotometer and their transmission bands determined.

It was found that polymerisation of the anthracene only occurred with filters that transmitted light of wavelength below about 400 m μ . No polymerisation occurred where the filters transmitted light of wavelength greater than 400 m μ . As glass itself transmits little light of wavelength below 300 m μ , the approximate range of radiation to which the anthracene method is sensitive lies between 300 and 400 m μ .

METHODS

Two methods of potential practical value were examined. In the first, a series of screw-capped bottles were filled with a solution containing about 5 g. anthracene per litre of benzene. To extend the range of the tubes to two or three days of bright sunlight, they were placed in boxes masked by metal strips in which apertures had been cut measuring $1 \times \frac{1}{4}$ in. to reduce the total light entering the bottles. After the masked boxes containing the bottles had been exposed to sunlight, the bottles were removed, their contents filtered rapidly and an aliquot of the filtrate diluted 250 times with pure benzene. The optical density of the diluted filtrate was then measured at a wavelength of 350 m μ on a spectrophotometer. From a standard graph plotted by measuring solutions of known anthracene content, the anthracene concentration of the solution in the bottle after exposure can be found.

For shade measurement on a large scale the above method suffers from some disadvantages. One of these is that the wavelength at which the diluted anthracene solution is measured (350 m μ) is the lower limit for most spectrophotometers (with glass diffraction gratings or prisms and tungsten light sources) where measurement is least sensitive. Also, the 250 times dilution needs to be accurate and losses due to evaporation of benzene kept to a minimum. For a large number of determinations, considerable quantities of redistilled benzene are required for diluting the solutions.

To overcome these difficulties, an attempt was made to determine the anthracene concentration directly in the exposed solution that originally contained 5 g. anthracene per litre of benzene.

Although the absorption maximum of anthracene in benzene occurs at 350 m μ , there is still considerable absorption by a concentrated solution (i.e. 5 to 6 g./litre) at 400 m μ . The accuracy of measurement is not so great at 400 m μ , but this is more than offset by eliminating inaccuracies due to dilution and lack of sensitivity of the instrument.

Accordingly, a series of bottles containing the anthracene solution were exposed to solar radiation as above, but the exposed solution was rapidly filtered directly into the spectrophotometer cuvette and the optical density of the solution immediately measured at 400 m μ . The anthracene content was then read from a standard graph prepared by measuring the densities of known solutions containing up to 6 g. anthracene per litre of benzene.

CALIBRATION

A Kipp Solarimeter connected to a Cambridge Thread Recorder was used to calibrate the two chemical methods. A series of duplicate bottles of anthracene solution were exposed to solar radiation for varying lengths of time over a period of three days and the radiation received during each period was read from the Kipp Solarimeter.

The residual anthracene concentration A in g. per litre was related to the total radiation received R, in g. cal. cm², by the equation:

$$R = 1076 - 1598 \log A \dots \dots \quad (1)$$

$r^2 = 0.989$. n = 21 observations for the first method, and

$$R = 1837 - 2274 \log A \dots \dots \quad (2)$$

$r^2 = 0.988$. n = 31 observations for the second method.

The good agreement of the chemical methods with the Kipp Solarimeter shows that they should be well suited for the measurement of radiation received by a particular plot over a period of from a few hours to several days. As the method is sensitive to only a small section (300-400 m μ) of the total solar spectrum, the good agreement obtained above is probably due to the measured band of radiation being a reasonably constant fraction of the total radiation over short periods of time.

By the use of the second method it is possible for a large number of exposed bottles of anthracene solution to be analysed comparatively easily and accurately.

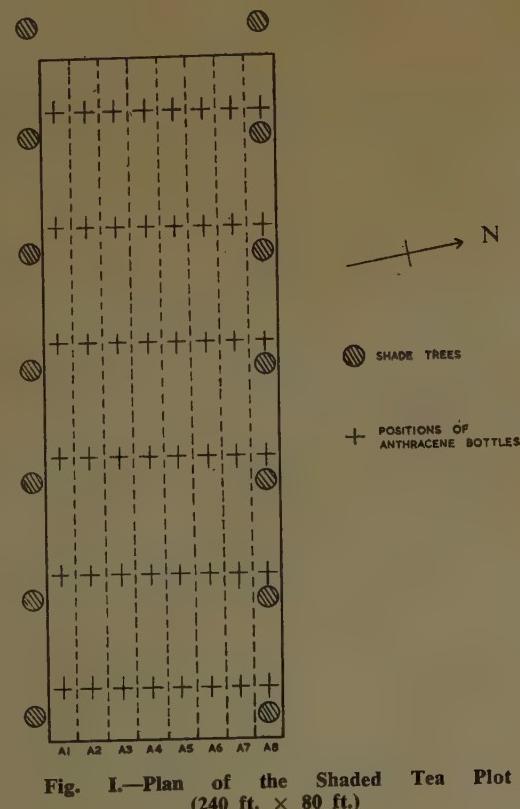
SHADE MEASUREMENT

A pilot experiment to measure shade was carried out on a plot of shaded tea growing at Limuru, Kenya, at an altitude of 7,400 ft.

The first of the two chemical methods was used to measure the anthracene concentration, as the second method had not been tried out at this stage.

The plot chosen was 240 × 80 ft. containing eight rows, each row consisting of 48 × 2 tea bushes (*Camellia sinensis*, Assam variety) planted 4 × 4 ft. The shade trees were unpolarded *Grevillea robusta* 35 to 42 feet high and planted 40 ft. apart in rows.

The screened boxes containing the bottles of anthracene solution were attached to stakes and placed at intervals (six in each row) level with the tops of the tea bushes as shown in Figure I. A set of bottles in boxes were placed in a completely unshaded position to give a measure of the total radiation over the measured period. After three days all bottles were removed and placed in a light tight box and then analysed for anthracene content on return to the laboratory. The radiation received by each bottle was then determined using equation (1). The mean radiation received by each row is shown in Figure II. It is seen that all rows received some shade in the course of three days, but that, as expected, the outer rows were more shaded than the centre rows, as the shade trees are along the outside.



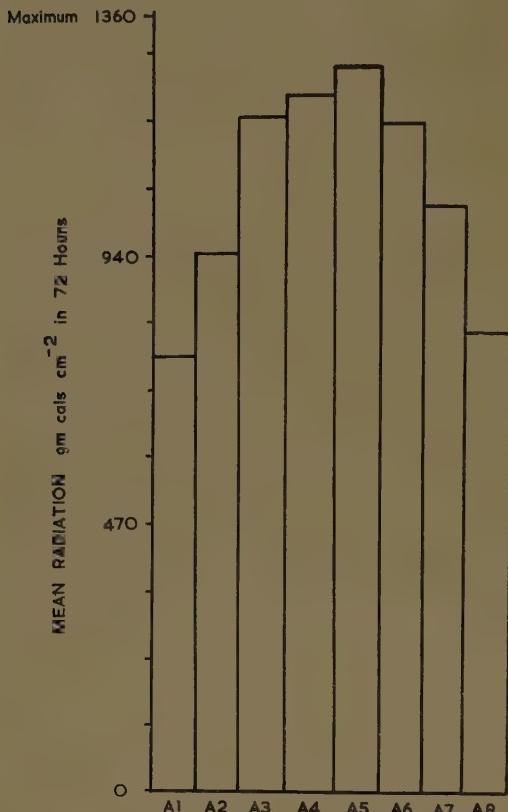


Fig. II.—Mean Radiation received by each row in the plot over the three-day period (completely unshaded control received 1360 g. cal. cm^{-2})

It is not suggested that this method would be suitable for measuring the intensity of light under heavy shade where spectral range may play an important role. It has, however, considerable promise in the analysis of the overall reduced intensity of radiation in lightly shaded areas such as that mentioned in the above experiment where, for a considerable part of the day, the tea bushes are freely exposed to a large measure of sky radiation and receive direct solar radiation for several hours when the shadows of the shade trees move away.

ACKNOWLEDGMENTS

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HIGH ALTITUDE LEY AGRONOMY IN KENYA

II—THE EFFECTS OF PHOSPHATES AND NITROGEN

By W. R. Birch, Grassland Research Station, Molo, Kenya

(Received for publication on 6th May, 1959)

The first phase of the work at the Molo Grassland Station has been concerned largely with species and strains of grasses and legumes suitable for leys, their establishment and their fertilizer requirements. Much of the work has therefore been done on a small plot basis and certain aspects of this work, particularly with fertilizers, is reported here. Other aspects, such as the weed problem of old arable land, have already been reported [1, 2] and will not be mentioned in any detail. The results that follow are based on experiments done at the Molo Grassland Station. Small plots of about 1/180 of an acre were generally used with three or four replications. As no facilities for dry matter determinations were then available, the results are generally based on weights of fresh material, taken by cutting with an Allen Scythe after suitable discards had been cut to avoid edge effects. Results expressed as fresh weights are open to many objections, but in this work only large differences between treatments are looked for as a guide for more precise work on a long-term basis later on. When legumes were used they were always inoculated with the appropriate inoculant, and high seed rates were often used to get a quick cover, and to reduce the necessity for hand weeding. Where superphosphate was used, this was invariably triple superphosphate of 40 to 42 per cent P_2O_5 content.

PHOSPHATE EFFECTS

The effect of superphosphate at 0, 63, and 189 lb. P_2O_5 an acre on the establishment of perennial ryegrass under broadcast conditions was investigated on very weedy old arable land (pH 5.3) in conjunction with different seeding rates and M.C.P.A. spray rates in a 3³ factorial experiment (see [2] for full details). Air-dry matter yields from a cut 2½ months after sowing, and another a month later, showed that the phosphate effects were linear, responses being 25 per cent greater when the M.C.P.A. was used for weed control; yields from the two cuts totalled were 10.3, 16.3 and 21.5 cwt./ac. (air dry) from the three rates respectively. The high phosphate rate thus doubled grass production during establishment and emphasises the need for large dressings of up to 450 lb. an acre of superphosphate for optimum vigour under broadcast conditions. Weed growth was significantly increased in the first cut by the phosphate dressings, but this was compensated for by decreases in weed yields in the second cut (unsprayed) with increasing phosphate dressings. Competition may thus be increased by phosphate applications on weedy land unless the weeds are controlled.

A second experiment, on a semi-microplot scale, compared triple superphosphate and basic slag at rates equivalent to 0, 94 and 188 lb. P_2O_5 an acre, on *Trifolium tembense*. This clover, an indigenous annual of hay type, had been sown the previous year and allowed to self-seed. It has since been discarded as being less productive than *Trifolium ruepeelianum*. The phosphate plots were 1/80 of an acre and they were split into sub-plots for observations on responses to trace elements, but only the phosphate responses are reported here. The fertilizers and phosphates were applied as top dressings before the clover germinated, without any cultivations. There were two replications on soil of pH 5.0.

The results from a single hay stage cut gave yields of 8.4 and 12.9 tons (fresh weight) an acre from the two superphosphate dressings, and 8.1 and 10.7 tons from the two slag dressings; control yields were only 0.7 tons an acre. Analysis of the data was done by using log transformations. The superphosphate effects are again approximately linear but the slag was less effective at the high rate than the superphosphate, though not quite significantly so. The phosphate x trace element interaction was highly significant. This experiment demonstrates again the overriding importance of phosphate, responses of this legume being of the order of 1200 and 1800 per cent with the 94 and 188 lb. an acre P_2O_5 rates of superphosphate respectively.

A third experiment, also under broadcast conditions, was done with the Bacchus Marsh strain of subterranean clover sown in April at a high seed rate of 23 lb. an acre on virgin land (pH 5.1). Triple superphosphate, Kenaf No. 1, and Basic slag were compared at

equivalent citric soluble phosphate rates of 0, 168 and 252 lb. P₂O₅ an acre (=400 and 600 lb. triple supers an acre). Uganda Rock phosphate of 2.4 per cent citric soluble P₂O₅ was also used at 67 and 98 lb. P₂O₅ an acre. There were four replications, and in addition to the above treatments two bare-fallow plots, one without phosphate and one bare-fallow with the high superphosphate treatment were included. The seed and phosphates were raked in and the plots rolled. Three cuts were taken, the first ten weeks after sowing, the second five weeks later, and the third six weeks after the second cut. In the first cut the responses were nearly linear, but this was not so in the second cut, except with the Kenaf. From the totalled yields shown in Table I, it may be concluded that the optimum rate is between 168 and 252 lb. P₂O₅ an acre (broadcast) but that the highest rates of superphosphate and Kenaf caused significantly quicker growth during the first ten weeks than the lower rates. For the three cuts totalled the higher rate of Kenaf, alone of the three phosphates, significantly outyielded the lower rate. The slag, on an average basis over the two rates, yielded just significantly less than the Kenaf or superphosphate. The Rock phosphate was relatively ineffective. It should be mentioned here that weighed and air-dried samples from the third cut showed that there was 3 per cent more moisture in the clover with the high phosphate dressings than in the control. The phosphate responses are thus slightly overestimated.

After the third cut the clover was rotavated twice to about four inches and Lampton Oats was drilled overall without any phosphate

immediately afterwards on 8th October, 1958. Only 2.6 inches of rain fell in the 20 days after sowing and thereafter it was abnormally dry, only 0.63 inches being recorded till mid-December, when 3.42 inches fell during one week. The oats started piping on 31st December, and they were cut and weighed on 2nd January, the results being shown in Table I. There were no significant differences between the oat yields from the different phosphate treatments (except for the Rock phosphate). Between rates of phosphate only the high slag dressing gave significantly greater yields than the low rate, but undue weight should not be given to this result because one plot of the high slag dressing gave an abnormally high response. The control yield (oats after clover without any phosphate) was significantly lower than any other treatment, and the bare-fallow (oats after no clover and no phosphate) significantly outyielded it. Of greater interest is the fact that the fallowed-with-phosphate treatment significantly outyielded all other treatments except the high slag.

The phosphorus (P) content of the clover in the third cut rose from 0.10 per cent in the controls to around 0.16 per cent with the low phosphate dressings, with only a small further increase with the high dressings, except with Kenaf. This is in line with the yield responses of the third cut. Phosphate uptake would appear to be greater from the less soluble phosphates than from the superphosphate, and it is of interest that though the rock phosphate did not stimulate clover yields very much the P content of the clover receiving rock phosphate was only 0.01 to 0.02 per cent less than that in the clover receiving superphosphate.

TABLE I.—EFFECT OF PHOSPHATES ON SUBTERRANEAN CLOVER AND OATS
Yields Tons an Acre F. Wt.

FERTILIZER	Rate lb./ac. P ₂ O ₅	CLOVER YIELDS				Oat Yields	% P (D.M.) ANALYSIS		% C.P. (D.M.) Oats	
		CUT					*Clover	Oats		
		1	2	3	Total					
Nil	0	0.8	4.1	5.1	10.0	4.0	0.10	0.18	20.7	
T. Supers.	168	5.6	8.5	10.4	24.5	7.0	0.16	0.16	17.2	
T. Supers.	252	6.9	8.2	11.1	26.2	7.0	0.17	0.17	17.0	
B. Slag	168	4.0	8.7	10.0	22.7	6.4	0.18	0.19	17.9	
B. Slag	252	4.9	8.4	10.8	24.1	7.9	0.21	0.20	17.9	
Kenaf 1	168	4.6	8.5	10.5	23.6	6.7	0.12	0.19	18.4	
Kenaf 1	252	6.2	9.5	10.9	26.6	7.0	0.21	0.19	17.0	
Rock	67	1.3	5.5	7.5	14.3	5.0	0.15	0.19	20.9	
Rock	98	1.7	5.8	7.6	15.1	4.9	0.15	0.18	19.3	
Fallowed	0	—	—	—	—	6.5	—	0.15	24.2	
Fallowed	252	—	—	—	—	9.7	—	0.14	21.1	
L.S.D. (P 0.05)	.. . . . .	0.9	1.6	1.1	2.3	1.2	*in 3rd cut.		
C of V %	.. . . . .	16	15	8	8	12.5			

The oat crop shows three interesting points. Firstly, the P content is less with superphosphate than with the other forms used. Secondly, P uptake from the fallowed plots was considerably less than from any other treatment despite one of the fallows having had 252 lb. P_2O_5 an acre seven months before; this phosphate has presumably been fixed in unavailable form quicker on the fallow than on the clover plots. Thirdly, there is an inverse linear relationship between total clover yields (X) and the crude protein percentage of the oats (Y) ($Y = -0.24 X + 23.41$, $P = 0.02$). This is not a reflection on the stage of growth of the oats with the various treatments; if this was so the oats on the fallow which gave the biggest yields would be expected to have the lowest crude protein, but this was by no means so and in fact the oats were pronouncedly greener on the fallows than elsewhere.

It may be concluded that even a vigorous clover well phosphated will not, under cutting conditions, in one season improve the growth of the crop immediately succeeding it. It is also clear that use of a clover inadequately phosphated may result in worse yields of the succeeding crop than is obtained from bare fallowing. Phosphate availability may be depressed by fallowing, but the soil nitrogen content raised compared with that under a cut clover.

NITROGEN EFFECTS

It is a commonplace that high altitude grass is often nitrogen deficient, so the following experiments were done to investigate the responses of ley grasses to artificial nitrogen under cutting.

The effect of sulphate of ammonia during the establishment of perennial ryegrass was investigated in a 3³ factorial with three replications on very weedy arable land. The sulphate of ammonia was broadcast two days after the grass seed had been drilled (with phosphate) and the first herbage cut was taken 2½ months after sowing; a second cut was taken a month after the first. The sulphate of ammonia significantly increased grass yields, each 2 cwt. an acre dressing increasing the total yields during the 3½ months from sowing by about 4 cwt. an acre (air dry). The nitrogen also decreased the weed yields by nearly a half (see [2] for details). For grass establishment there is thus little doubt that artificial nitrogen could be used with advantage.

The effects of different types of nitrogenous fertilizers were investigated in a cutting experiment by using perennial ryegrass in its second and third years after being under grazing in its first year. Sulphate of ammonia, N.A.C. fertilizer and Urea were applied at 0, 61.5 and 123 lb. N an acre each year as one dressing in April and also as a split dressing, half in April and half in June. An overall dressing of 200 lb. an acre of triple superphosphate was applied at the beginning of each year. The experiment was a 7 x 7 latin square with split plots. The top six inches of soil was sampled for pH determinations (three replicates) before the experiment started and twice thereafter at the end of each season in the dry weather. The initial soil pH was 5.6.

TABLE II.—EFFECT OF FORMS OF NITROGEN ON PERENNIAL RYEGRASS

Fertilizer	YIELDS, TONS AN ACRE F. WT.					
	1957			1958		
	A	B	Mean	A	B	Mean
Nil ..	3.7	2.7	3.2	3.1	2.8	3.0
S/A. 1 ..	6.8	6.4	6.6	5.7	4.5	5.1
S/A. 2 ..	10.6	11.1	10.8	8.8	7.0	7.9
N.C.A. 1 ..	7.7	7.9	7.8	5.1	5.4	5.2
N.C.A. 2 ..	11.2	10.5	10.8	8.8	7.0	7.9
Urea 1 ..	6.2	6.5	6.3	4.7	4.5	4.6
Urea 2 ..	9.5	9.8	9.6	7.2	6.1	6.6
Mean ..	7.9	7.8	—	6.2	5.3	—

L.S.D. (P=0.05)

Nitrogen means = 1.4 0.7

Nitrogen at same time = 1.9 1.0

C of V 11% (whole plot basis) 8%

A=All-in-one dressing

1=61.5 lb. N/ac.

B=As split dressing

2=123 lb. N/ac.

The results from three cuts each year are shown in Table II. Another cut could have been done each year but grass yields were very low towards the end of the season and there was little residual nitrogen effect after the third cut. It will be seen that under cutting second- and third-year ryegrass yields poorly (three tons an acre of fresh weight only), but the nitrogen effects, which were linear, doubled grass yields with the low and trebled yields with the high dressings in the first year; the second-year responses were slightly less. The first year the low rate of N.A.C. fertilizer gave very nearly significantly greater yields than the low sulphate of ammonia dressing, but at the high rate yields from the two fertilizers were the same. At the low rate the urea gave significantly lower yields than that from the N.A.C., and nearly significantly less than the N.A.C. and sulphate of ammonia at the high rates. The second year the urea at the

high rate gave significantly less grass than the other high rates.

No differences between the split and all-in-one fertilizer mean responses were obtained the first year, but the all-in-one mean of the latter significantly outyielded the former in the second year, which was comparatively dry towards the end of the season.

The effects on grass quality were marked. Crude protein contents went up from 8 to 10 per cent in the controls to 20 per cent with the high dressings (all-in-one) and to 14 per cent with the low dressings in the first cut. The low nitrogen dressings gave half this or slightly less. In the third cut, i.e. after the second half of the split applications, there was only a 1 to 2 per cent increase in crude protein, top dressing being thus relatively ineffective in mid-season; at this time there was no residual effect on crude proteins from the all-in-one application. The urea gave 2 to 3 per cent less crude protein than the other fertilizers.

The calcium contents of the grass are of some interest. In the second year these were from 0.05 to 0.15 per cent less in the grass receiving sulphate of ammonia than when receiving the neutral urea or basic N.A.C. fertilizer. This is also reflected in the soil pH changes; at the end of the second year there was a decrease of 0.48 to 0.60 units depending on whether all-in-one or split dressings of sul-

phate of ammonia were used. Decreases in soil pH on plots receiving the other fertilizers, and on the controls, did not exceed 0.18 units, there being slightly less change on the N.A.C. plots than elsewhere. The experiment shows that nitrogen is the main factor which limits grass growth.

The next experiment was done to compare the yields, under cutting, of Westerwolths (commercial), H.I., N.Z. Italian and S22 Italian ryegrasses with and without nitrogen. These are quicker growers than perennial ryegrass. There were four replications with split plots. It was decided to use large regular 4 cwt. an acre dressings of N.A.C. fertilizer to see if and when deficiencies of other nutrients would limit grass yields. The grasses were drilled at 13 lb. an acre at the end of May with 1 cwt. of triple superphosphate on clean land. The first 4 cwt. dressing was applied six weeks after sowing and cutting started a month later, three cuts being taken at six- to eight-week intervals this first season. The second season another 4 cwt. dressing was applied at the end of April (together with $1\frac{1}{2}$ cwt. triple superphosphate overall) and another two cuts were taken. Another N.A.C. dressing was then applied followed by two more cuts; 2 cwt. of muriate of potash was applied overall in August of the second season.

The results of the first six cuts are shown in Table III; after the sixth cut the Westerwolths ryegrass had nearly died out on the

TABLE III.—EFFECT OF NITROGEN ON ITALIAN TYPE RYEGRASS
Yields, Tons an Acre F. Wt.

	Westerwolths	H.I.	N.Z.	S22	Mean
Cuts 1 to 3:					
+N ..	17.3	12.7	13.2	11.8	13.8
-N ..	10.5	5.2	7.0	6.2	7.2
Mean ..	13.9	9.0	10.1	9.0	
	L.S.D. ($P = 0.05$) Grass means 3.6				C of V 15 %
	L.S.D. ($P = 0.05$) Grass means at same fertilizer level 4.0				
Cuts 4 to 6:					
+N ..	15.5	12.8	13.5	11.7	13.4
-N ..	2.1	1.5	1.9	1.5	1.8
Mean ..	8.8	7.1	7.7	6.6	C of V 5 %
	L.S.D. ($P = 0.05$) Grass means 1.0				
	L.S.D. ($P = 0.05$) Grass means at same fertilizer level 1.3				
Total Cuts 1 to 6:					
+N ..	32.8	25.5	26.7	23.6	27.1
-N ..	12.7	6.7	8.9	7.7	9.0
Mean ..	22.7	16.1	17.8	15.6	C of V 3 %
	L.S.D. ($P = 0.05$) Grass means 1.4				
	L.S.D. ($P = 0.05$) Grass at same fertilizer level 1.6				

control plots but was still fairly vigorous on the top dressed plots. With nitrogen the Westerwolths significantly outyielded the other grasses by six to nine tons an acre over the two seasons; S22 yielded significantly less (but was more persistent) than the others, the H.I. and N.Z. Italian equalling each other in yields. Without nitrogen the Westerwolths yielded significantly more in the first season than the others (except N.Z. Italian), H.I. being the lowest yielder. Over the two seasons H.I. was the worst yielder in the absence of nitrogen.

Chemical analysis showed that without nitrogen the crude protein content of the grasses fell steadily from 20 per cent in the first cut to 10 per cent in the sixth cut. With nitrogen the crude proteins of the first cut were around 23 per cent, and these fell to 15 per cent and 10 per cent in the subsequent two cuts. Reapplication of nitrogen at the beginning of the second season raised the crude proteins to 19 per cent in the first cut but these fell to 9 per cent in the second cut and the reapplication of nitrogen only raised them to 15 per cent. There was thus a progressive reduction in crude protein contents despite the nitrogenous manuring. Calcium (Ca) contents were around 0.50 per cent there being no significant drop during the experiment. Phosphate (P) contents, however, fell from 0.30 per cent in the first cut to the low figure of 0.13 per cent at the end of the experiment regardless of whether nitrogen was used or not.

After the sixth cut the grasses on the nitrogen plots started to develop a marked chlorosis and stopped growing despite a reapplication of nitrogen in the third season. The chlorosis was not cured by applications of potash or common salt but a pronounced effect on colour, and a significant positive effect on growth was obtained from the application of 1 cwt. an acre of magnesium sulphate. Analysis of the Westerwolths and H.I. ryegrass before the $MgSO_4$ application revealed that their sulphur contents were around 0.07 per cent (of D.M.), from the nitrogen plots, and 0.12 per cent, from the control plots, i.e. the sulphur contents had been reduced by a half by the nitrogen fertilization. Analyses of the grass after the $MgSO_4$ and Na Cl applications showed that apart from a 0.09 per cent increase in sodium (Na_2O) content of the H.I. ryegrass receiving 4 cwt. an acre of common salt which did not increase yields, there were marked increases in the sulphur contents of the

grasses receiving $MgSO_4$. S contents of the grasses were increased from around 0.03 per cent to 0.20 per cent and this can be the only explanation of their resumption of normal colour and vigour. It was, however, not possible to continue the experiment further because of weed growth and because the controls died out. It may be concluded, however, that sulphur deficiency is unlikely to limit grass production except under conditions of heavy nitrogen applications. Lack of nitrogen limited grass growth to 2 tons of fresh weight an acre in the second year. With nitrogen, yields of 11 to 15 tons a year can be obtained under cutting and the experiment demonstrates that, as in the previous one, nitrogen deficiency limits grass yields severely.

Finally the effect of nitrogen and phosphorous on the yield of Westerwolths ryegrass hay was investigated in a 3 x 3 experiment. Large plots of 100 ft. x 10 ft. were used because the original intention was to take a seed crop, but because of dry weather it was decided to cut for hay instead. The grass was drilled at the end of April at 30 lb. an acre with 1 cwt. an acre triple superphosphate on soil of pH 5.4.

At the end of June, two months after sowing, the grass was up to 8 in. high and very dense. It was then grazed hard and mown, the fertilizers being applied immediately afterwards. The treatments were basic slag at 0, 3, and 6 cwt. an acre and N.A.C. nitrogenous fertiliser at 0, 2, and 4 cwt. an acre in all combinations with the phosphate. The grass was cut the first week in October in the early flowering stage when about 3 ft. high, cured in the field and then weighed. The nitrogen plots were much greener than the others and though the grass, particularly on the high phosphate-nitrogen plots had recovered from some earlier lodging, the cutting was difficult and so the yields of those plots are underestimated. Hay yields were of the order of 65 cwt. an acre, the greatest yield of 75 cwt. being obtained from the high nitrogen-low phosphate combination. Phosphate alone gave no more than 1.2 cwt. an acre increase in yields. Despite the reasonably low error variance (C. of V. 11 per cent) there were no significant differences between treatments. It is clear, however, that with nitrogen, hay yields can be of the order of 75 cwt. an acre, while phosphate alone causes a negligible increase in yields. Samples of the grass (from two of the three replicates) were

taken for analysis and the results showed an 8 to 9 per cent C.P. content, which is quite a high one for a pure grass hay. The highest crude protein content was 11.9 per cent, from the high nitrogen-high phosphate combination. Fibre content was between 26 and 28 per cent, carbohydrate 49 to 55 per cent and calcium 0.32 per cent of the dry matter. The phosphate figures were extremely low, 0.05 per cent in the controls, even the 6 cwt. slag dressing only increasing the P content by 0.02 per cent. After the hay cut, the grass grew away strongly on the nitrogen plots and as a whole the experiment was grazed intermittently providing a considerable amount of grazing, until mid-January, 1959, when it was ploughed up. It may be concluded that even on poor land Westerwolths ryegrass will provide good hay yields and a considerable amount of grazing (at the initial grazing the yield was estimated at 6 to 7 tons of green matter an acre). There were beneficial effects from nitrogenous top-dressing but high slag dressings caused only a negligible increase in the low phosphate content of the hay.

DISCUSSION OF RESULTS

Firstly, attention should be drawn to the great importance of phosphate for grass and clover growth. In Fig. 1 is shown the superphosphate response curves from three experiments reported above, and for comparison results from S. Australia [3 and 4], and the Grassland Station, Kitale [5]. All the results are first year ones, i.e. in the year of broadcast phosphate application to seeded grass or clover. The most important comparison is between the slope of the curves, this being smallest for Molo and greatest for the two Australian subterranean clover areas. The optimum phosphate rate at Molo is probably reached between 160 and 200 lb. P_2O_5 an acre; in the Kitale experiment at around 100 lb., and in the S. Australian experiments at 50–80 lb. P_2O_5 an acre. H. W. Dougall [6] showed that 60–70 lb. was optimal for establishing grasses (mean result from different species and altitudes) but the Molo results are not in line with his findings. H. F. Birch [7, 8 and 9] showed that the phosphate responses and phosphate uptake of established grass in Kenya, was correlated with the per cent saturation of the base exchange capacity (B.E.C.) of acid soils (and to a slightly lesser, though significant extent, to soil pH). Similarly wheat responses to phosphate were generally greatest when the B.E.C. saturation was

lowest (around 40–50 per cent). In the present work the soil data show that the base saturation of the grassland station's soils is around 30–40 per cent and seldom exceeds 50 per cent, with pH's of 4.9 to 5.5. It is thus pertinent to ask why the responses to phosphate were comparatively small in the present experiments. There are three most likely possibilities. Firstly the timing of the herbage cuts might affect the responses, but this is considered unlikely since the three species used gave similar, flat, response curves. Secondly, other nutrients, and in particular nitrogen, might limit responses to phosphate. Unfortunately critical P x N establishment experiments have not yet been done, but established grasses have shown no large and significant P x N interactions from top dressings. Furthermore, ley grasses generally grow vigorously and yield up to 6 tons an acre of green material of around 20 per cent crude protein quite soon after sowing. Although the grass does benefit from nitrogenous top dressings during establishment, the responses are not large enough to suggest that nitrogen limits phosphate responses during establishment. The third and most likely explanation is that climatic factors, and in particular low temperatures, limit the uptake of phosphate and hence yield responses are smaller than one would expect on these soils of low base saturation. Whatever the reason it is clear that quite large phosphate dressings are needed at Molo for optimum growth.

It was suggested in part I of this series that at least half, and more likely three quarters of the high altitude arable land have pH's and base saturations like those of the Grassland Station, Molo. The economic problem of establishing and maintaining good legume growth at the high altitudes by phosphate applications can thus be appreciated, and especially so, when it is realized that twice or nearly three times as much phosphate will be needed as in S. Australia where subterranean clover has revolutionized agriculture at the expense of only 2 cwts. of single superphosphate an acre annually (cf. curves in Fig. 1). Furthermore if the generalization is true that the high altitude soils are more acid than those lower down more phosphate will be needed at the high altitudes, and it must follow from this that ley farming there will not continue to expand until either far cheaper phosphate is available, or until it has been proved that dressings of the order of 3 cwt. of superphosphate (42 per cent

P_2O_5) annually for at least some years are economic in terms of immediate increases in carrying capacity, or produce long term effects on following crops.

FIG. 1
PHOSPHATE RESPONSES

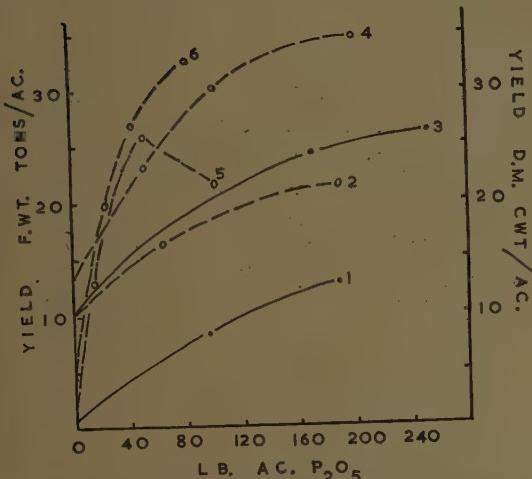


Fig. 1.—Phosphate responses for *T. tembense* (1), *P. ryegrass* (2) and sub-clover (3) at Molo; Nandi *Setaria* (4) at Kitale and sub-clover (5) and (6) in S. Australia. Dry weights are shown as —●— and fresh weights as —○—.

Turning now to discuss the nitrogen effects, it will be recalled that large responses were obtained in the experiments reported above. Grass yields in the second and third years were of the order of 1 to 3 tons F. Wt. a year without nitrogen, compared with 10 to 15 tons a year when nitrogenous top dressings were used. Responses range from 6 to 11 lb. of dry matter (D.M.) per lb. of nitrogen applied during the establishment of perennial ryegrass, to 17 to 19 lb. of D.M. from established perennial ryegrass and 24 lb. of D.M. per lb. of nitrogen applied from Italian type ryegrasses (allowing 15 per cent D.M. in the green weights). These results, and others unpublished, indicate that the quicker-growing grasses respond better than the slow growers. Under English conditions J. L. Wheeler [10] quotes the average response to nitrogen from swards cut for silage or dried grass as being about 12 lb. of D.M. per lb. of nitrogen applied. This is somewhat less than that found locally but it must be emphasized that the English responses come from pastures which are often already yielding as much, or more, before top dressing than the same grasses yield locally when top dressed. For example, the approximate yields of D.M.

from the perennial and Italian ryegrasses receiving 600 to 800 lb. of sulphate of ammonia a year were 3,600 and 4,600 lb. of D.M. a season under cutting. The latter is only a moderate yield by temperate standards. It is a valid criticism that yields under cutting are lower than those obtained under grazing with full return of dung and urine and in temperate climates responses under grazing may go as high as 50 lb. of D.M. per lb. of nitrogen applied. Nevertheless from many observations made on the performance of high altitude grasses under grazing it is considered true that the return of dung and urine only stimulates the grasses when returned at high rates such as can be obtained by intensive sheep folding. This is only practical on a comparatively small acreage. The conclusion is therefore this, that with the exception of a handful of favoured farms on soils far better than the average, there is a nitrogen deficiency which may be conservatively estimated to be around 150 lb. of nitrogen annually. This would make for a moderate output of grass; to raise production to good New Zealand standards nearly 400 lb. of nitrogen would be needed.

As production at the high altitudes is so limited by nitrogen it is interesting to compare results from lower altitudes. In Fig. 2 are shown yield data of unfertilized grass from Kabete, Kitale and Molo, with the mean daily rainfalls per day between each cut. Two points emerge from this comparison. Firstly, at Kabete, with its long and short rain seasons, yields follow exactly in step with the rainfall figures. The other extreme is Molo, where no such correlation exists except possibly in the first season. The Kitale results are intermediate. The explanation of these different results is probably contained in H. F. Birch's [11] and H. L. Richardson's [12] work. The former has shown how greatly alternating dry and wet conditions affect the release and breakdown of soil organic matter. The latter showed that under grass the mineralizable soil nitrogen followed inversely the seasonal temperatures and that the fluctuations in soil nitrate and soil ammonia were small and independent of seasonal changes, i.e. there was an equilibrium between the rate of production of ammonia under grass and its removal. The Molo soil temperatures of around 56° F. and the absence of any but minor seasonal soil temperature fluctuations under grass would thus mean not only that mineralizable soil nitrogen is produced at a steady

rate throughout the year, but also that it is produced in small quantities because soil temperatures are always low. The less marked alternations of dry and wet seasons at Molo, combined with low temperatures may thus be responsible for the lack of any flush of growth at the beginning of the rains (cf. Kabete) and the low yields after establishment. It is of some historic interest in this connexion that Boyd Orr [13] showed in 1931 that grass at Molo did not show a flush of crude protein at the beginning of the rains such as was found at lower altitudes.

As a result of low temperatures the organic nitrogen may be expected to accumulate steadily because it is not broken down to an available form. There is a suggestion that that this may well be so from the soil analysis data of the Highland Fertilizer Scheme [14]. The mean organic matter content of 27 high altitude wheat soils is 6.9 per cent, which may be compared with a mean of 4.8 per cent from 79 samples from medium altitudes. Total nitrogen means were 0.32 and 0.22 per cent respectively but it is difficult to separate from such a comparison, climates and soil types.

Temperature differences may also explain the second point from Fig. 2, i.e. the difference between the slope of the curves at Molo, and at Kitale; the former being concave and the latter convex to the axis in the first year. Whatever the reasons, it is clear that the seasonal pattern of growth certainly differs between cold wet (Molo), and warm dry (Kabete) climates, and that nitrogen deficiency is of greater importance at the high altitudes than lower down.

This discussion may, therefore, be summarized by saying that though the needs for large amounts of phosphate and nitrogen are obvious, responses to the former may be limited by climatic factors, while deficiency of the latter is most certainly due to similar causes.

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FIG. 2

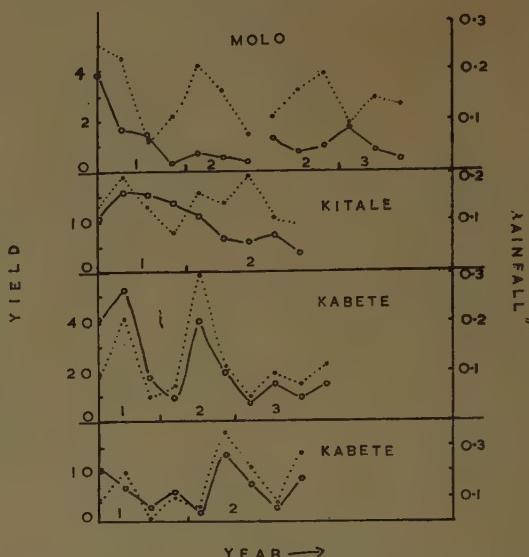


Fig. 2.—The relationship between yield, ○—○, and rainfall, ●—●, at Molo (ryegrass), Kitale (average of Rhodes, Molasses and N. Setaria) and Kabete (Napier grass, upper and Hyparrhenia rufa, lower)

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TRACE ELEMENTS IN SOME EAST AFRICAN SOILS AND PLANTS

I—COBALT, BERYLLIUM, LEAD, NICKEL AND ZINC

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Kikuyu, Kenya

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During the past few years trace element analyses of soils and plants have been carried out by the Spectro-chemistry Division of E.A.A.F.R.O. with the objects of (1) obtaining basic data on the trace element content of the more important soil types and plant species, (2) investigating whether trace elements are concerned in particular field problems and (3) elimination trace elements as a factor in some such problems. A considerable quantity of data has been accumulated and the purpose of this series of papers is to describe several interesting features which have emerged. The trace elements considered here are those readily soluble in dilute acetic acid and all, with the possible exception of beryllium, have well established places in deficiency or toxicity studies in plant or animal nutrition. The importance of these elements is discussed briefly below when each is considered separately. Copper which is concerned jointly with cobalt in the deficiencies occurring in the Rift Valley will be considered in a later paper as the data accumulated so far is insufficient to justify comment.

SAMPLES

The results from 131 samples of topsoil are considered and it cannot be claimed that these represent a complete study of the distribution of trace elements in Kenya soils. There are, however, sufficient to justify comment on the more important agricultural areas including the Central, Rift Valley and parts of the Southern and Nyanza Provinces. Except for a few samples, information is lacking on the largely unproductive area between the coastal belt and the Machakos District, the Masai District and the Coast and Northern Provinces. The main sources of the samples have been the Soil Survey Division of E.A.A.F.R.O. and the Kenya Departments of Agriculture and Veterinary Services.

In addition to topsoils, 37 samples of subsoil and a further 59 samples from deeper horizons have been analysed.

METHODS

Dilute acetic acid was adopted in the first instance as the soil extractant for the combined reasons that Hudson (1941) had claimed to have proved that "Nakuruitis" was due to a cobalt deficiency, and that Stewart, Mitchell and Stewart (1941, 1942) and Patterson (1946) showed that this reagent gave suitable differentiation between soils supporting pastures of deficient or adequate cobalt content. Following extraction by acetic acid, the soil is removed by filtration and a mixture of the trace elements is concentrated in a matrix of aluminium oxide by the method of Mitchell and Scott (1948). This concentrate is then analysed spectrographically for cobalt, beryllium, lead, nickel and zinc by the variable internal standard method of Davidson and Mitchell (1940).

For some soils extractions using the disodium salt of diamino-ethane-tetra-acetic acid (E.D.T.A.) were carried out. This reagent is a more powerful extractant for some metals due to its ability to form chelates with them. After a pretreatment the extracts were subjected to the same procedure as the acetic acid extracts.

RESULTS

Unless stated otherwise all references to trace element contents imply acetic acid extraction. When considering the general distribution of trace elements individual analytical results have little meaning and so the data have been presented in Table I as the number of soils from each Province falling within a given range of concentration for each element. This form of presentation is suggestive of a statistical frequency distribution but such an interpretation is not valid due to the differing numbers of samples taken from the various areas. However, this remains the most practicable presentation as attempts to arrange the data according to soil type revealed too many inconsistencies to be of value, for example red friable clays from Muguga contain about 0.1

p.p.m. cobalt while similar soils from the Nandi Escarpment yield up to 9 p.p.m. An exception is found in the volcanic ash soils of the Rift Valley floor and the alluvium derived therefrom and for this reason these soils are listed separately from the remaining soils of the Province.

DISCUSSION

It can be seen in Table I that cobalt and beryllium exhibit a much wider range of concentration than lead, nickel and to a lesser extent, zinc. The range of cobalt recorded so far is from less than 0.02 p.p.m. to 9 p.p.m. and for beryllium less than 0.02 p.p.m. to 6.5 p.p.m. For lead a few low values have been recorded but with the exception of one sample with 5.4 p.p.m., 119 samples have values lying within the range 0.16 to 1.2 p.p.m., that is within a concentration range of 8:1. The nickel values are generally higher than the other elements except zinc but the highest value of 5.7 p.p.m. is well below the highest cobalt value and the nickel contents of 111 samples lie within a 8:1 concentration range, that is between 0.32 and 2.5 p.p.m. Comparable figures for cobalt (0.08 to 0.63 p.p.m.), beryllium (0.16 to 1.2 p.p.m.) and zinc (4 to 31 p.p.m.) are 72, 76, and 85 samples respectively. The level of zinc in the extracts is 10 to 100 times greater than the other elements and range from 1 to 98 p.p.m.

Cobalt.—In their review Russell and Duncan (1956) state that up to that time no data were available for soils or pastures of the "Nakuruitis" areas. It is believed that the first cobalt values to be published were those of the writer (1957). Up to the present time 31 samples from the floor of the Rift Valley have been analysed and Table I reveals that 24 of these show cobalt contents of less than 0.08 p.p.m. These samples cover the 100-mile distance from the Kedong Valley to Rongai and various points across the width of the valley. These figures clearly indicate the deficient or marginal cobalt status of the Rift Valley soils. Soils from areas adjacent to the Rift Valley have also been found to be low in cobalt, including Muguga, Molo, and the escarpment opposite Mbaruk. Soils from the Athi and Narok plains, from Sotik and alluvium deposited by the Thika and Tana Rivers have also been found to be low in cobalt. As mentioned above deficiency of copper complicates the cobalt deficiency in the Rift Valley and the copper status of the soils will be discussed in a subsequent paper.

Away from the Rift Valley it seems that, with the exceptions already noted, most soils contain cobalt in the middle ranges, 0.1 to 0.5 p.p.m., but instances of higher contents have been found. The soils recorded in Table I as containing 0.64 p.p.m. cobalt or more almost invariably come from the wetter hilly regions of Kenya and Table II shows the areas from which these samples came. While the Machakos region cannot be described as wet in the same sense as the Aberdare Mountains or Mount Kenya, the samples with high cobalt were all from hilltops. Other samples from this region away from the hilltops had cobalt contents ranging from 0.06 to 0.5 p.p.m. The very high values recorded from the Nandi Escarpment are of special interest as according to Swaine (1955) there are the highest recorded from any part of the world except for some Scottish soils derived from serpentine. The author is informed by the Geological Survey of Kenya that no serpentine rocks have been recorded in this area.

Although the low cobalt values obtained by acetic acid extraction reflect with reasonable reliability that part of the soil cobalt which is available to pasture, there is evidence that further supplies exist in these ash soils but in a less available form. Extraction by E.D.T.A. solution yields cobalt concentrations of up to 2 p.p.m., that is, more than 20 times that extracted by acetic acid. Mitchell, Reith and Johnston (1957) found that E.D.T.A. extracted less cobalt than did acetic acid from some Scottish soils. This has been found to be the case with some soils of higher cobalt content when the E.D.T.A. extracts ranged from less than the acetic acid figure to about 2.5 times that figure.

Beryllium.—For many years beryllium has been regarded rather as a chemical oddity and the only use to which it had been put was the production of beryllium bronze. Since the development of atomic reactors, beryllium has found use as a moderator and as a material for the cans for nuclear fuel and arising from this work beryllium and some of its compounds have been found to be highly toxic. An account of the various forms of berylliosis is given by Lieber (1958) who records that the standard of purity laid down by the U.K. Atomic Energy Authority for the air in their establishments is that there shall be less than 2 millionths of a gram beryllium in one cubic metre of air. Points of agricultural interest are that Steinburg (1946)

TABLE I.—TRACE ELEMENTS IN KENYA SOILS

p.p.m.	NUMBER OF SAMPLES IN EACH GROUP									
	Average	<0·04	0·04– 0·08	0·08– 0·15	0·16– 0·31	0·32– 0·63	0·64– 1·2	1·3–2·5	2·6–5·1	>5·1
COBALT	0·58									
Province:										
1 Coast	0·48	—	—	—	1	2	1	—	—	—
2 Southern	0·72	1	2	1	4	1	2	2	—	—
3 Central	0·42	—	4	7	1	6	2	—	—	—
4 Northern	0·15	—	1	1	1	—	—	—	—	—
5A Rift Valley Floor	0·07	14	10	4	3	—	—	—	—	—
5B Rift Valley Other Areas	0·90	—	4	4	11	12	4	—	—	2
6 Nyanza	1·0	—	2	3	6	4	2	—	1	1
BERYLLOUM	0·76									
1	0·04	1	3	—	—	—	—	—	—	—
2	0·32	—	1	3	7	2	4	1	5	1
3	1·45	—	4	2	1	4	—	—	—	—
4	0·08	1	—	2	—	7	8	4	—	1
5A	0·75	1	—	3	7	9	8	7	—	1
5B	0·81	1	1	4	6	3	5	—	1	—
6	0·50	3	1	2	4	3	5	—	—	—
LEAD	0·60									
1	0·56	—	—	—	—	3	1	—	—	—
2	0·40	2	1	—	3	7	2	—	—	—
3	0·54	—	—	—	4	14	3	1	—	—
4	0·52	—	—	—	—	3	—	—	—	—
5A	0·51	—	—	—	4	22	5	—	—	—
5B	0·81	1	1	1	15	14	3	—	—	1
6	0·61	—	—	—	2	10	6	1	—	—
NICKEL	1·2									
1	1·1	—	—	—	—	—	3	1	—	—
2	1·6	—	—	—	—	4	5	2	1	1
3	1·6	—	—	1	1	2	5	10	2	—
4	2·3	—	—	—	—	—	—	1	—	—
5A	0·64	—	—	—	7	14	5	5	1	1
5B	1·3	—	—	—	1	8	12	14	1	—
6	1·2	—	—	—	—	2	9	8	—	—
ZINC	17	<4	4–7	8–15	16–31	32–63	>64			
1	6·5	—	3	1	—	—	—			
2	8·1	4	4	6	1	—	4			
3	32	3	4	3	3	5	—			
4	7·4	—	2	1	—	—	1			
5A	17	8	7	5	5	5	1			
5B	12	8	11	6	11	—	—			
6	18	3	3	3	6	4	—			

Note these values for Zinc
are 100-fold those above

TABLE II.—HIGH COBALT SOILS

PROVINCE	LOCATION	Cobalt Content p.p.m.	Beryllium Content p.p.m.
Coast	Shimba Hills	0·7	0·04
Southern	Mua Hills, Machakos District	1·7, 1·8	0·29, 0·23, 0·28
	Kanzalu Range, Machakos District	2·4	0·20
	Yatta Plateau, Machakos District	1·1	0·7
	Kiteta, Machakos District	1·5	0·15
	Limuru	1·0	< 0·03
Central	Mount Kenya, above Embu	0·7	0·09
	Aberdare Mountains, above Fort Hall	1·6, 1·9	< 0·03, < 0·03
Rift Valley	Nandi Escarpment	8·8, 9·0	0·13, < 0·03
	Londiani Forest Reserve	1·8	0·30
	Uasin Gishu, near Elgeyo Escarpment	1·4	0·28
	Kitale Experiment Station	1·4, 2·0	0·28, 0·22
Nyanza	Near Nandi Escarpment	1·0, 8·5	0·06, 0·28
	Tinderet Forest Reserve	4·6	0·34
	Busia	1·0	0·12

showed that beryllium could replace magnesium in the growth of *aspergillus niger* and later Kovaleva and Shkol'nik (1954) showed that beryllium as a nutrient enabled seed to be produced with barley under conditions of boron deficiency which otherwise prevented the formation of seed. For soils very little has been published but Swaine (1955) quotes total beryllium as ranging from 0.1 to 40 p.p.m. while the change in total beryllium content down a profile has been studied by Leininger (1957) and Mitchell (1957). In the latter paper beryllium is not mentioned as being present in acetic acid extracts of a profile containing 5 to 15 p.p.m. total beryllium. From Table I it can be seen that beryllium amounting to several parts per million has been extracted from some Kenya soils and the range of concentration is similar to that for cobalt. A general observation is that those samples high in cobalt are usually low in beryllium and vice versa. Of the 131 soils in Table I, 54 containing more than 0.5 p.p.m. beryllium have less than 0.5 p.p.m. cobalt and a further 27 soils having more than 0.5 p.p.m. cobalt have less than 0.5 p.p.m. beryllium, there being only three samples containing more than 0.5 p.p.m. of each element. Conversely a soil low in cobalt or beryllium does not necessarily have a high content of the other element.

A study of the distribution of these samples suggests that those high in beryllium come from areas where weathering has been slight such as the semi-arid Rift Valley and adjacent escarpment areas. Also soils with impeded drainage from Marindas, Yatta and Laikipia show high beryllium contents. Samples from regions where the soil is more heavily weathered contain only small quantities of beryllium, this being true of all the soils high in cobalt shown in Table II except for the Yatta plateau soil. The above considerations suggest that during the decomposition of the soil minerals beryllium is released early with comparatively little weathering while with more vigorous weathering the beryllium is leached out and cobalt becomes more available. Theoretical support for this is given by consideration of the oxidation potentials, that for $\text{Be}:\text{Be}^{++}$ being 1.7 volts and for $\text{Co}:\text{Co}^{++}$, 0.277 volt, these indicating the greater ease with which beryllium can take ionic form.

Lead.—The toxic effects of lead in animal nutrition are well known but the uptake of

lead by plants is often little affected by the lead content of the nutrient medium. Campbell *et al* (1950), however, found high lead contents (3-32 p.p.m.) in the soils of areas where disseminated sclerosis occurred. For the Kenya soils analysed thus far normal values have been obtained.

Nickel.—The usual problem involving nickel in plant nutrition is one of toxicity and a typical example is that described by Hunter and Vergnano (1952). These workers found 50-400 p.p.m. nickel in some Scottish soils which was toxic to oats, clover, potato and cabbage. On the other hand Roach and Barclay (1946) found that spray applications of nickel solution increased significantly yields of wheat, potato and broad beans growing in marsh soil. Up to the present there has been no indication of deficient or toxic levels of nickel being encountered in Kenya soils although the Rift Valley soils can be seen from Table I to have lower nickel contents than those of other areas. Soils derived from serpentine can have high nickel contents as well as high cobalt.

Zinc.—The general average of 17 p.p.m. for the Kenya soils is of the same order as those referred to by Swaine (11 and 14 p.p.m.) but the six values greater than 64 p.p.m. are rather higher than the highest quoted by Swaine for acetic acid extracts. No relationship has yet become apparent between zinc concentration and locality or soil type.

For 34 of the soils in Table I, the results of zinc determinations using *aspergillus niger* have been provided by Pinkerton (1959). Statistical analysis has shown that there is a connexion between the two methods which is significant at $P=0.001$ but the correlation coefficient r was only 0.61 and $r^2=0.37$. Visual examination suggests that accumulation of more data and segregation according to soil type might yield better agreement between the methods.

DISTRIBUTION DOWN PROFILES

The analyses of the subsoils revealed lower concentrations of the trace elements than the surface soils in most instances. Seven soil profiles have been analysed, four of soils under forest cover, one profile having carried tea for 32 years and two recently put under tea and described by the growers as "hut sites". The results are shown in Table III. The Kericho forest profile and the old tea profile are of the same soil type and are within 100 yards of each other. It is interesting to see

that 32 years of growing tea has made virtually no difference to the trace element contents although the exchangeable bases in the surface soil of the tea profile had decreased from 6 m.e./100 g soil to 4 m.e./100 g soil. The pH of the topsoil of the tea profile had increased from 4.2 to 4.6 but at greater depths the bases and pH were almost the same for both profiles. The picture presented by the data is that in the first 2'-4' zinc and nickel decrease to between $\frac{2}{3}$ and $\frac{1}{4}$ of their content in the surface soil. In the case of cobalt this is true for only three profiles, those from the wetter regions. The remaining four profiles show an increase in cobalt content with depth but in three instances following an initial decrease. All the profiles from the Kericho area show an increase in lead content with depth.

TABLE III.—DISTRIBUTION OF TRACE ELEMENTS IN PROFILES

	0-6"	2'	4'	6'	10'	>15'
Cobalt						
1 Muguga Wattle	0.04	0.03	0.10	n.s.	0.26	0.27
2 Muguga Gum	0.06	0.05	0.04	0.02	0.02	0.06
3 Aberdare Forest	1.6	0.5	0.5	0.5	n.s.	n.s.
4	0.33	0.25	0.20	0.20	n.s.	n.s.
5	0.40	0.35	0.25	0.25	n.s.	n.s.
6	0.25	0.15	0.20	0.25	n.s.	n.s.
7	0.15	0.15	0.25	0.40	n.s.	n.s.
Beryllium						
1	4.6	5.0	3.5	n.s.	2.1	1.3
2	0.5	0.6	0.6	0.6	0.7	0.7
3	<0.03	<0.03	<0.03	<0.03	n.s.	n.s.
4	<0.03	<0.03	<0.03	<0.03	n.s.	n.s.
5	<0.03	<0.03	<0.03	<0.03	n.s.	n.s.
6	0.2	0.2	0.1	0.1	n.s.	n.s.
7	<0.03	<0.03	<0.03	<0.03	n.s.	n.s.
Lead						
1	1.6	1.3	1.2	n.s.	1.0	0.8
2	0.5	0.6	0.6	0.5	0.5	0.6
3	1.2	1.2	1.0	0.4	n.s.	n.s.
4	1.2	1.2	1.6	1.8	n.s.	n.s.
5	0.6	1.1	2.0	2.0	n.s.	n.s.
6	0.3	0.6	0.6	0.7	n.s.	n.s.
7	0.3	0.5	1.5	1.4	n.s.	n.s.
Nickel						
1	1.0	1.0	0.7	n.s.	0.6	0.5
2	1.3	1.4	1.0	0.4	0.3	0.5
3	1.5	0.6	0.4	0.3	n.s.	n.s.
4	0.9	0.4	0.2	0.2	n.s.	n.s.
5	1.0	0.4	0.3	0.4	n.s.	n.s.
6	1.3	1.7	1.0	1.3	n.s.	n.s.
7	1.3	0.9	0.3	0.2	n.s.	n.s.
Zinc						
1	37	25	14	n.s.	11	17
2	45	20	20	12	15	12
3	35	14	5	5	n.s.	n.s.
4	20	14	5	5	n.s.	n.s.
5	20	10	8	5	n.s.	n.s.
6	30	17	6	5	n.s.	n.s.
7	23	5	4	4	n.s.	n.s.

n.s.=not sampled.

CONCLUSION

The trace element status of Kenya soils in so far as they are represented by these samples appears to be generally similar to soils of other parts of the world but with some interesting exceptions. Soils from the Rift Valley low in acetic acid soluble cobalt seem to be a product of insufficient weathering rather than a low total cobalt and arising from this it is obvious that data on the total trace element content of the soils would be of great value. It is hoped that a method for these determinations will be instituted at a later date. Beryllium appears as an element of some interest in the weathering of soils and once again total beryllium contents would be of value. With the wide range of climatic conditions prevailing in East Africa the possibility exists of a more detailed investigation of the influence of weathering on trace element availability, indications of which are given here. Progress is being made with similar studies of the soils of Uganda and Tanganyika, the findings of which will be published when sufficient data have been accumulated.

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NOTES ON VETERINARY TOXICOLOGICAL ANALYSIS

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With the general use in East Africa of dips based on arsenic and toxaphene, these two toxic agents are the most frequent causes of poisoning in livestock. Arsenic, in particular, is so highly toxic that even with normal precautions in dipping an occasional fatality is liable to occur. Of 91 cases of suspected poisoning investigated in this laboratory in a year, in 33 of which toxic agents were identified, 26 were poisoning by arsenic, four were toxaphene poisoning and only three involved other known poisons. It is therefore of advantage, in veterinary toxicological analysis, to be able both to identify arsenic and toxaphene readily and to be able to determine, with a minimum waste of time, whether they are present in lethal quantity.

In routine work arsenic is very easily and quickly detected by the Reinsch Test [1], but its determination by the usual methods involves the destruction of organic matter. There are several processes which can be applied for this operation, but they all involve the use of comparatively large quantities of "arsenic-free" materials and are all time-consuming, in spite of the fact that no great accuracy is required in the final result: the final stage will often consist of the semi-quantitative Gutzeit procedure. In the method for the determination of arsenic outlined in Part 1 of this paper, it is claimed that results of comparable accuracy are obtained by a simple procedure which uses less time and materials and does not involve the destruction of organic matter.

Toxaphene is produced by the chlorination of the hydrocarbon camphene. It is a mixture of chlorine derivatives which steam distils slowly as a semi-solid and gives the Fujiwara Test for chlorinated hydrocarbons [2]. Whereas most other chlorinated hydrocarbons encountered in toxicological analysis are single compounds and are easily identified in the steam distillate from an acidified sample, toxaphene is normally difficult to identify. In Part 2 of this paper a method is given by which toxaphene may be identified in the steam distillate with reasonable certainty before applying, for quantitative estimation, one of the standard methods for determination of organic chlorine.

In Part 3 are described two liquid-liquid extractors which offer certain advantages over the standard patterns in routine toxicological analysis.

1. THE SEMI-QUANTITATIVE ESTIMATION OF ARSENIC IN TOXICOLOGICAL SAMPLES

In this method the Reinsch Test, which functions in the presence of organic matter, is continued until all the arsenic present in the sample has been deposited on copper. The deposit is then removed chemically from the copper and transferred in solution to a Gutzeit apparatus for the determination of arsenic according to the Sanger and Black modification [3].

Reagents (these should be as far as possible "AsT", otherwise Analytical Reagent grade)

Hydrochloric acid, diluted to (a) 6 per cent and (b) 8 per cent.

Copper foil, cut into pieces approximately 1 cm. square. A small hole is made in one corner of each piece for suspending it on a hook of platinum wire.

Sodium hydroxide solution, 20 per cent.

Hydrogen peroxide solution, 30 per cent (100 volume).

Stannous chloride solution, 10 per cent in 6 per cent hydrochloric acid.

Cupric sulphate solution, 5 per cent.

Zinc, granulated.

Lead acetate cotton wool. This may be purchased in prepared form, or may be made by soaking absorbent cotton wool in a 2 per cent solution of lead acetate and drying *in vacuo* over sulphuric acid.

Mercuric chloride test papers. Whatman No. 41 filter papers are steeped in a 5 per cent ethanolic solution of mercuric chloride, hung to drain and dry in air and cut into strips 3 mm. wide. The lower part of each sheet, where, after draining, the reagent is more concentrated is discarded.

Apparatus

For the Reinsch Test a 250 or 300 ml. Erlenmeyer flask is used. A length of about 5 inches of platinum wire is mounted in the end of a glass rod, also about 5 inches long and the glass is bent, about 1 inch from the end holding the platinum, to an angle of about 30 degrees. In use the glass rod is hung on the edge of the flask, the free end of the platinum wire being bent to a hook for supporting the copper foil in the liquid.

For the Gutzeit determination any of the usual forms of apparatus may be used, but the design shown in Figure 1 has been found most convenient for the quantitative addition and washing in of the test solution. In this design a 150 ml. flat-bottomed flask with a short neck is used for the reaction. A tube carrying the tap funnel, for the addition of the liquids, fits into the ground neck of the flask and this tube, in turn, carries the exit tube holding the test paper. Papers 3 mm. wide are used and, accordingly, the inside diameter of the exit tube should be between 3.2 and 3.5 mm.

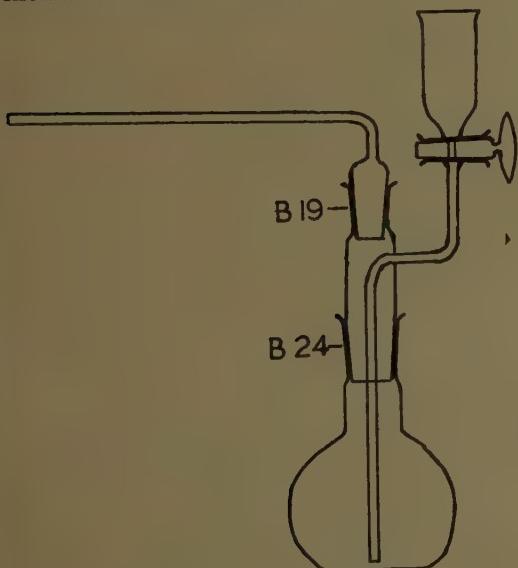


Fig. 1.—Gutzeit Apparatus

Procedure

Reinsch Test.—5 g. of the material under investigation is covered with 6 per cent hydrochloric acid, a square of copper foil hung in the liquid and sufficient heat is applied to keep the acid boiling gently; the volume is kept constant by the occasional addition of distilled water. It has been found by trial that this strength of acid is the optimum for the

quantitative deposition of arsenic and, since practically no hydrochloric acid is lost on boiling, water rather than dilute acid should be added for keeping the volume constant (compare reference 1). If after half an hour no discolouration is visible on the copper, no arsenic is present.

If a slight stain is formed on the copper, the test is repeated using a larger quantity (e.g. 20 g.) of the material; if a moderately heavy stain appears, the boiling is continued with the original amount; if the stain is very heavy and forms immediately boiling commences, the procedure should be carried out with only 1 or 2 g. of the material. In any case, allow the boiling to continue for a total of one hour, keeping the volume constant, then remove the copper and substitute a new square. Continue this process until the material produces no more stain. At this stage all the arsenic from the sample will have been transferred, mainly as copper arsenide, to one, more usually two, or sometimes three squares of copper.

Removal of the arsenic from the copper. The squares of copper are rinsed with distilled water and placed in a 25 ml. tall form beaker or conical flask. Add 1 ml. of 20 per cent sodium hydroxide solution and shake gently to wet all the copper surfaces with this reagent, then add 2 drops of 30 per cent hydrogen peroxide. Shake gently and, if the reaction does not become vigorous within about 10 seconds, warm very gently for a moment. The whole reaction is completed within a matter of seconds, leaving the copper bright and the arsenic in solution as sodium arsenate. Pour the liquid into a clean 50 ml. Erlenmeyer flask and wash in with three portions of about 2 ml. of water. Add 1 ml. of stannous chloride solution and dissolve any stannous hydroxide precipitate by careful dropwise addition of concentrated hydrochloric acid. Raise the liquid to the boil and boil gently for half a minute: this converts the arsenate to arsenite, a process which has been found to take place very slowly in the Gutzeit determination.

Gutzeit Determination

Prepare a Gutzeit apparatus by putting five or six pieces of granulated zinc in the flask, adding 2 drops of copper sulphate solution and placing in the B19 cone of the exit tube first a wad of dry absorbent cotton wool and then, below it, a wad of lead acetate cotton wool. A strip of test paper is inserted in the narrow outlet tube to within about 1 cm. of the bend.

With the stopcock open, pour the cooled solution containing the arsenite into the funnel of the apparatus and wash in with three portions of about 3 ml. of water. Close the stopcock, pour 25 ml. of 8 per cent hydrochloric acid into the funnel and run it into the flask; then add a further 25 ml. of 8 per cent hydrochloric acid in the same way. Close the stopcock. After 45 minutes the process may be considered complete. The stain produced on the test paper is compared with stains produced from solutions containing known amounts of arsenic pipetted into a prepared Gutzeit apparatus but, since there is less dilution of the arsenic solution, adding 6 per cent hydrochloric acid in place of 8 per cent. Suitable values for the standards are from 0.005 to 0.2 mg. of arsenious acid.

Sensitivity and Accuracy of the Method

It is found that amounts of arsenious acid of the order of 0.005 mg. are detectable. Quantities up to 0.05 mg. are estimated to within about 20 per cent and an amount of arsenious acid greater than 0.05 mg. can be estimated to within about 10 per cent. During several months' use of the method we have usually found it possible to decide whether the small quantities of arsenic found in samples were residues due to regular arsenic dipping (e.g. quantities of the order of 0.2 parts per million of arsenious acid in bovine ruminal contents), or whether the larger amount present represented the probable cause of death.

Other Elements which Give the Reinsch Test

Other elements which give a positive result in the Reinsch Test are not likely to cause any confusion in this method. Mercury and silver give a silvery layer on the copper which could not be mistaken for the arsenic stain. Bismuth gives a black or grey-black stain, but the treatment with sodium hydroxide and hydrogen peroxide does not remove the stain readily from the copper and even after the addition of extra hydrogen peroxide the copper remains black except at the edges. The presence of large amounts of sulphur compounds in a sample will often produce a black or brown stain, but this also is not dissolved in the sodium hydroxide-hydrogen peroxide treatment.

Antimony gives a purplish-black stain, usually distinguishable by its colour, which dissolves in the same manner as the arsenic

stain; but in the Gutzeit procedure the mercuric chloride paper is much less sensitive to stibine than to arsine and the stain on the test paper is usually grey to black, not yellow or brown, and spreads lightly over a large area of the paper. Since less than 1 mg. of antimonious acid is not detectable on the mercuric chloride paper, it is hardly likely that the amount of antimony deposited on copper in the Reinsch Test, carried out as above, will give a positive result in the Gutzeit determination.

Advantages of the Method

Although the quantitative deposition of arsenic on the copper may take over two hours, this is still much less time than is required for the decomposition of organic matter by processes employing nascent chlorine, nitric acid or perchloric acid. The method of Strzyzowski, employing magnesium nitrate and magnesium oxide [4] can be carried out in about two hours, but requires constant attention for most of this period, whereas in the above method the time spent on supervision is negligible. Further, all methods for the destruction of organic matter require the use of comparatively large amounts of materials. The process of removal of arsenic from the copper takes only a few minutes, employs such small quantities of reagents that there is no risk of adding any detectable amount of arsenic with them, and gives the arsenic in a form and quantity of solution suitable for applying the Gutzeit procedure without further treatment. Above all, the whole process gives the same degree of accuracy as any of the methods for the destruction of organic matter followed by a Gutzeit determination.

2. THE IDENTIFICATION OF TOXAPHENE

As indicated in the introductory remarks, toxaphene is normally difficult to identify on account of the absence of definite physical properties such as melting point. The percentage of chlorine has been found in most cases to be useless as an aid to identification, as it is usually impossible to separate the toxaphene in a sample completely free from other material. With the following simple procedure, however, a satisfactory identification of toxaphene can be obtained.

If the steam distillate from acid medium gives a positive reaction in the Fujiwara Test, any of the following substances, besides toxaphene, may be present: chloroform, carbon

tetrachloride, tetrachloroethylene, chloral hydrate, chlorbutol, hexachloroethane, DDT or benzene hexachloride (gamma or mixed isomers). All of these substances can be readily identified by their physical properties. Should none of them be found to be present, a fair amount of the steam distillate, e.g. 2 l., is extracted with light petroleum ether (40–60° C.). To this extract is added a petroleum ether washing of the condenser and the combined liquids are dried over anhydrous sodium sulphate. Filter, and shake the petroleum solution gently in a separating funnel with successive small portions of concentrated sulphuric acid until the last portion of sulphuric acid remains colourless. If much emulsification takes place in the sulphuric acid layer, the combined portions of the latter are shaken with fresh petroleum ether, which is then added to the main petroleum ether solution. Filter and evaporate off the solvent on a water bath.

If toxaphene is present, the removal of contaminating substances by the two processes of steam distillation and sulphuric acid treatment is sufficiently complete for the residue, consisting mainly of the more volatile constituents of toxaphene, to have the characteristic smell of toxaphene.

3. LIQUID—LIQUID EXTRACTORS FOR ROUTINE SEPARATIONS IN TOXICOLOGICAL ANALYSIS

In the extractions normally carried out with ether and chloroform for the separation of non-basic poisons, alkaloids and glycosides, the use of separating funnels frequently results in the formation of emulsions, with consequent loss of time and difficulty of operation. Continuous liquid—liquid extractors give efficient extraction and seldom cause emulsion formation, but in their usual forms they have certain disadvantages which the extractors described below are designed to eliminate:—

(a) Extractor for solvents lighter than water.
This extractor, illustrated in Fig. 2, follows the conventional design but is provided with a stopcock for running off the liquids. This dispenses with the need for dismantling the apparatus when an acid-aqueous liquid, after extraction with ether, has to be rendered alkaline and re-extracted. For regulation of the quantity of solvent used, it is necessary to construct the apparatus to a suitable size for the routine adopted, e.g. in this laboratory aqueous-acid extraction is carried out so as to finish with 100

to 110 ml. of solution, and the extractor is made to hold approximately 130 ml. up to the overflow tube. A round-bottomed, 250 ml. flask with B29 neck is used and is heated in a mantle controlled with an energy regulator.

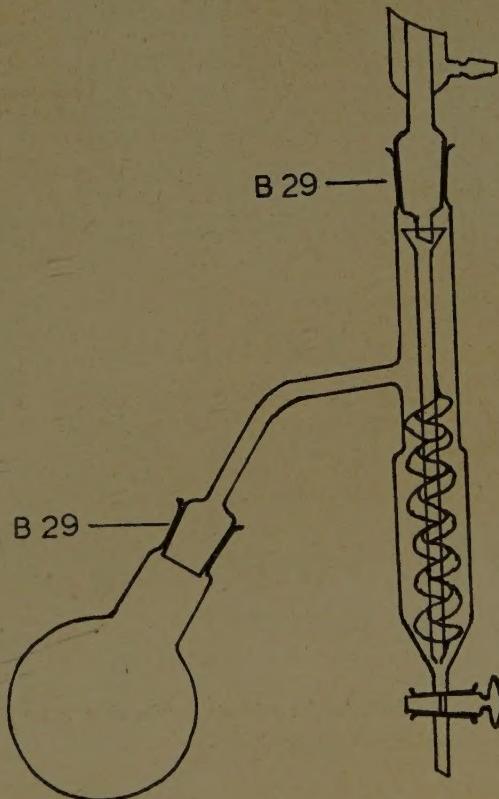


Fig. 2.—Extractor for solvents lighter than water

(b) Extractor for solvents heavier than water.
Conventional patterns of extractors for this purpose have the disadvantage that the amount of solvent used is that necessary to operate the flow rather than the amount most convenient for handling with the extract. In the apparatus shown in Fig. 3, the body of the extractor is a pear-shaped bulb instead of the usual straight tube, enabling the extractor to work efficiently when tilted at an angle. The method of use is as follows:—

With the extractor upright, introduce the required amount (30 to 50 ml.) of solvent, connect the flask and pour the aqueous liquid carefully into the top of the extractor. During this addition keep the solvent from flowing into the flask,

if necessary by tilting the apparatus in the direction away from the flask. When the aqueous liquid has all been added, attach the condenser and then tilt the apparatus in the other direction, allowing the solvent to rise in the narrow

return tube and overflow into the flask. Adjust the tilt so that finally about 10 ml. of the solvent remains below the aqueous liquid. The extractor is then worked in this position.

Construction should be such that when the extractor is in any working position the return tube should still slope upwards from the body of the extractor. If it takes a downward slope for the last part of the return, siphoning will take place.

For the extraction of 100 to 150 ml. of aqueous liquid, 250 ml. is a suitable size for the bulb of the apparatus. A stopcock is fitted for ease of draining.

ACKNOWLEDGEMENT

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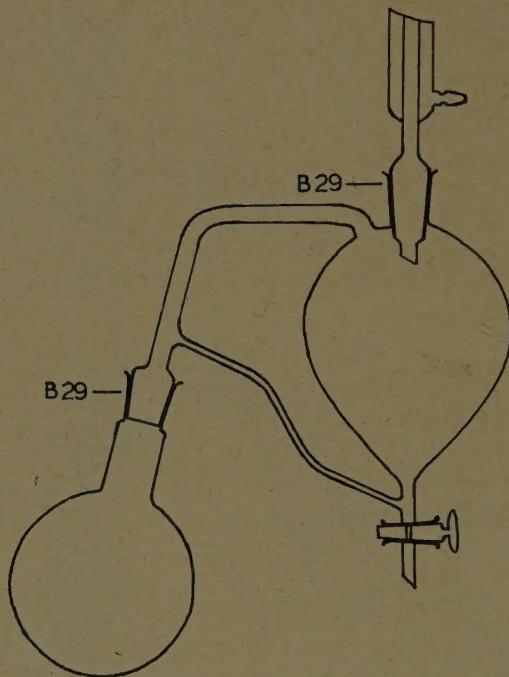


Fig. 3.—Extractor for solvents heavier than water

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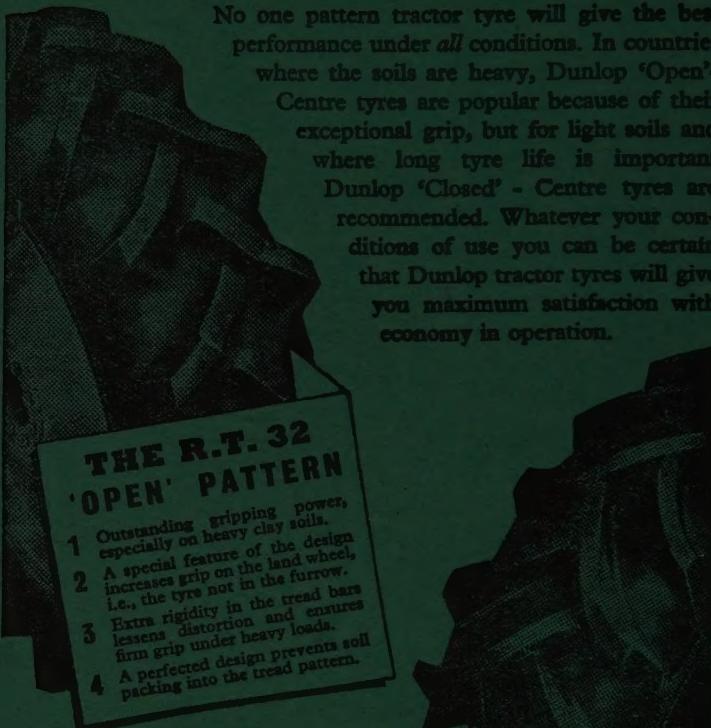


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